POWER

Volume 60 New York, September 9, 1924 *No* 11

The N. A. S. E.

ANOTHER year has gone by and for the forty-second time the National Association of Stationary Engineers assembles in convention.

To have lived forty-two years and to have maintained a membership of over twenty thousand, this Association must have served a useful purpose.

Its slogan throughout these years has been Education, improving the knowledge and skill of its members in the principles and practice of stationary engineering.

And it has been a potent factor in manning the industries and institutions of the country as their demands for power grew, as their plants increased in size and complexity, and as the importance of uninterrupted and economical operation became more insistent.

The owners of some of the largest and best-operated power plants in the country owe the men who have made them so to the N.A.S.E., and numbers of the outstanding power-plant engineers of the country owe their success to the urge and interest and information acquired at the meetings of their respective subordinate associations.

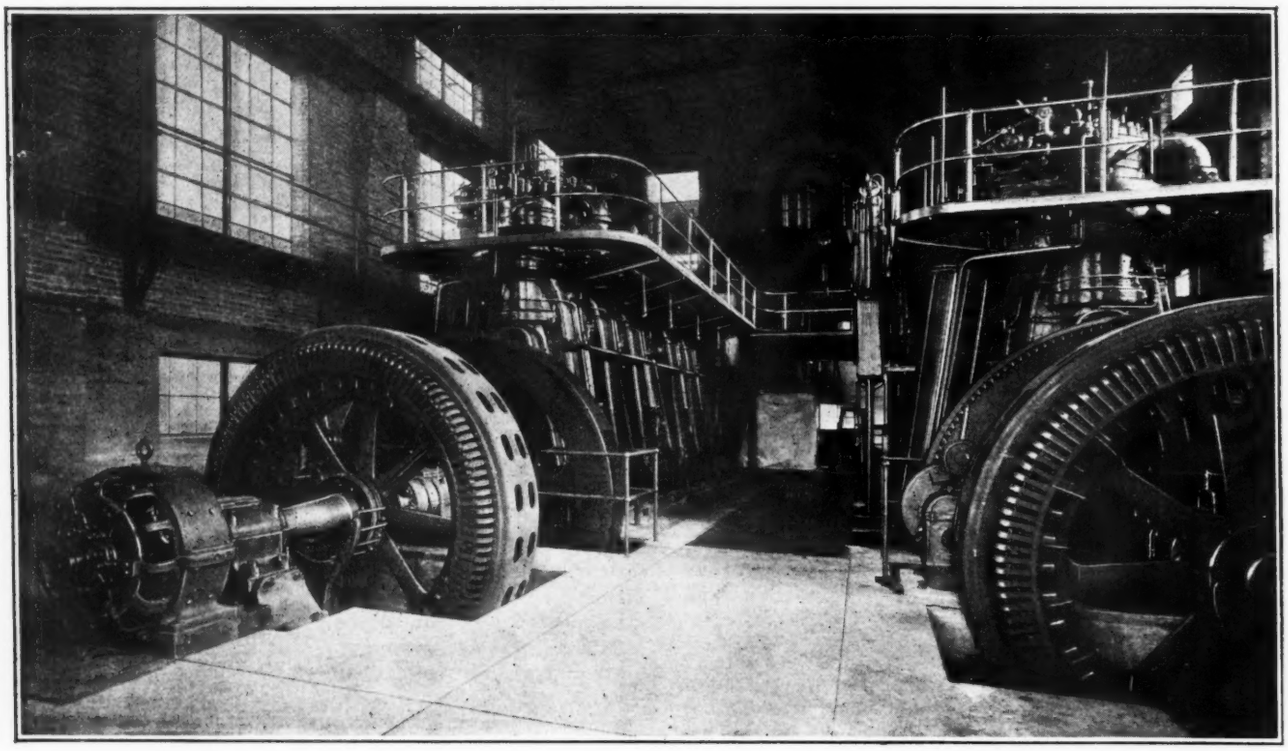
Some of these associations have been singularly successful in retaining an interested membership and in turning out good men. The associations that have done best are those that have been blessed with local leaders who knew what they wanted and what their fellow members ought to have, and who had the faculty of bringing it out in an interesting and understandable way.

There is an unfortunate sense of implied deficiency that goes with the word "education." Not everybody wants to admit that he needs education in the art or profession that he practices. And the N.A.S.E. is not an educational institution in the sense of supplying elementary knowledge of the art of which it is the exponent, except by encouraging co-operation among and the use of established facilities by those of its members who may need it.

But just as the learned societies are educational in instigating research and promulgating its results among their members, in discussions that interpret discoveries and achievements and trends, so this body of twenty-odd thousand power-plant engineers ought, out of the richness of their experience, out of the problems that they meet and proposed means for their solution, out of the records of their performances and their striving for better results, to produce a fund of mutually helpful and generally interesting information regarding the development, status, possible performance and best operation of the industrial and institutional power plants of the country.

It is by bringing out these possibilities of its diversified and specially competent membership that the National organization can best supplement, for the general good, the excellent work done locally by its subordinate associations.

F. R. Low



Diesel-Engine Stand-by Plant at Iron River, Michigan

Two-unit Diesel plant of 2,150 kilovolt-ampere capacity installed to supplement water power in preference to addition to existing steam plant. The cost of plant was $187.74 per kilowatt. Average economy 0.676 pounds of oil per kilowatt-hour.

FORESEEING a profitable market for power to the iron mines in Iron County in the Northern Peninsula of Michigan, which could be supplied by developing the water power in the numerous streams of this region, the Peninsula Power Company, of Madison, Wis., was organized in 1911. Its first hydro-electric plant at Twin Falls on the Menominee River was ready for operation in 1913. Operating under a head of 42 ft., this plant has an aggregate capacity of 9,500 hp. in five horizontal twin-turbine units. During the same year a stand-by steam plant was installed at Iron River, which at that time was the center of distribution and the two plants interconnected by a 66,000-volt transmission line about 36 miles long.

At the beginning the service was largely a mining load with the exception of current wholesaled to the cities of Iron Mountain and Iron River. Pumping at the mines must continue whether they are in operation or not, so that the load is continuous and fairly uniform. The mining load gradually increased and the system was arranged to supply other towns, sawmills, and in 1915 a large industrial load at the plant of the Kimberly-Clark Paper Co. at Niagara. This required additional generating capacity and the installation of three more hydro-electric stations: One on the Brule River, near Florence, with a capacity of 9,300 hp. in three vertical units operating under a head of 60 ft.; another on Pine River with two units aggregating 5,700 hp. and a head of 93 ft.; and a third plant on the Sturgeon River, near Loretto, of 1,200 hp. capacity in one vertical unit and a head of 65 ft. The two plants last named were designed for automatic operation. Three-phase 60-cycle current is generated at 2,300 volts. In the other stations the generator voltage is 6,600, which is stepped up to 66,000 volts to supply the general transmission system, with the exception of certain local circuits supplied at generator voltage and the Sturgeon River plant, from which current is transmitted at 13,000 volts.

Gradually, a water-power capacity of 25,700 hp. in the four stations has been provided, and additions have been made to the steam plant to carry that portion of the load for which water was not available. This plant is operated intermittently, but principally during the fall and winter or the low-water period of the year. With the growing load of the system the steam plant had gradually assumed a burden up to its capacity, so that in 1923, when the Kimberly-Clark load had been doubled to a contract for 2,800 hp., representing about 25 per cent of the entire load on the system, it became necessary either to enlarge the steam plant or to provide additional power in some other way. The decision eventually made was to install a Diesel-engine plant adjacent to the steam station.

By this time the steam plant had six boilers of the

Scotch-marine type, each containing 4,400 sq.ft. of heating surface and equipped with a down-draft furnace having plain grates, hand-fired. The working steam pressure was 160 lb. with no superheat. Coal and ash were handled manually. In the generating room there were three turbo-generators with direct-connected exciters, one rated at 2,000 kw. and the other two each capable of carrying 1,000.

Figs. 2 and 3 show typical load curves for weekdays and Sundays for each of the five stations and the total combined load. It will be seen that the weekly load on the Iron River plant ranges close to 3,000 kw., and the total combined load runs from 6,000 to 9,000 kw., averaging about 7,500. The Sunday load is smaller, the combined load averaging about 4,000 kw. and the load on the Iron River plant in the vicinity of 800. There is little variation throughout the year, as the constant mine load aggregates larger than the city and industrial services.

To insure reasonable economy, it would have been necessary to remodel the steam plant; in other words, install new boilers equipped with stokers, build a new chimney, provide coal- and ash-handling facilities and increase the generating capacity by 5,000 kw. in one unit. This would have required re-arrangement of the building, so that the estimated cost was close to that of a new Diesel engine plant. Also the work would have extended over a considerable period, so that certain of the steam units would have been out of service when needed to carry the load. Another factor to be considered was the fuel. Storage space for coal on the present site was limited to 2,500 tons, and with the plant burning 600 to 800 tons per week, the reserve was not sufficient to tide over the delays in transportation caused by the heavy winter snows in this region. Lake coal is burned at the plant, and the price ranges from $8 to $9 a ton. On the other hand, a year's supply of oil for a Diesel-engine plant could be stored on the premises and purchased at the lowest market price. The cost of the fuel was another factor favoring the Diesel plant by a ratio of more than two to one. A recent contract showed that oil could be purchased at the source for 2c. per gal., which with freight charges of 3.85c. per gal. brought the total cost per gallon delivered to 5.85c. Operating data incorporated in the article show that on the average 11 kilowatt-hours were obtained per gallon, so that the unit fuel charge is 0.53c. Assuming 3 lb. of the high-grade Lake coal used per kilowatt-hour, which is a figure actually obtained at the plant, and an average cost of $8.50 per ton, the kilowatt-hour fuel item amounts to 1.275 cents.

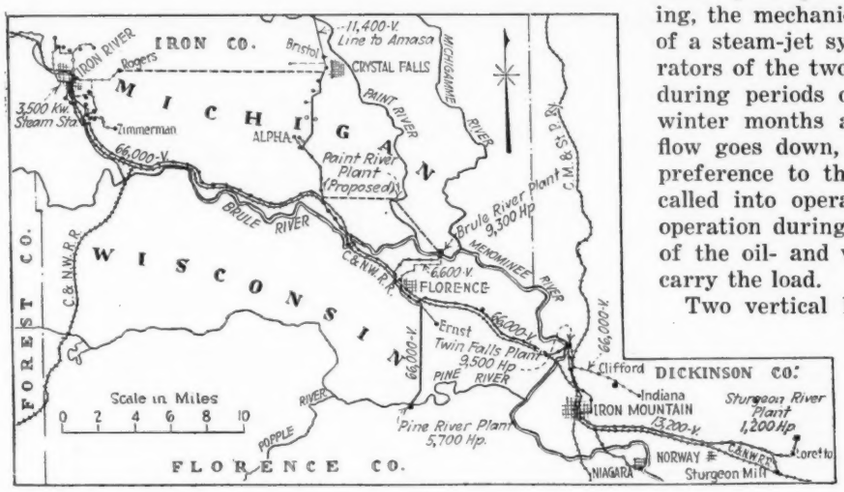


Fig. 1—Map showing plants and distribution system of the Peninsular Power Company

With storage capacity and the cost of fuel, labor conditions, economy and the ability to start quickly, an important factor with a mine load, all favoring a Diesel-engine station, it was decided that this type of prime mover should supply the additional capacity required. The steam plant has been retained, however, and its economy of operation improved by a thorough overhauling, the mechanical handling of coal and the provision of a steam-jet system to remove the ashes. The generators of the two plants will be paralleled and operated during periods of low water which occur during the winter months and summer droughts. As the river flow goes down, the Diesel engines will be started in preference to the steam plant, but the latter will be called into operation when necessary and continue in operation during the time when the combined capacity of the oil- and water-driven plants is not sufficient to carry the load.

The intermittent operation of the steam plant involved a labor difficulty. An operating crew of about 30 men was required for three eight-hour shifts, and as most of the men were not retained during the idle period, it was difficult to find a sufficient number to operate the boiler plant when operation was resumed. Fortunately, the company had in its employ three men familiar with Diesel-engine operation, so that with the installation of the Diesel-engine plant, no additions to the operating force were required. These men are retained the year around and are engaged in general maintenance work during periods of non-operation.

Two vertical Diesel engines of the two-stroke-cycle type, each rated at 1,250 hp., form the prime-mover equipment of the new plant. These engines drive 1,075-kva. 60-cycle 6,600-volt three-phase generators with direct-connected exciters, 180 r.p.m. being the normal speed.

Fuel oil is brought to the plant in tank cars and delivered on the spur track, which is long enough for unloading three cars at a time. Steam coils to insert in the tank cars during the colder weather are provided, and pumps in the basement of the steam plant transfer the oil to the concrete storage tank. A swivel outlet from the storage tank is provided so that the oil may be drawn from any desired level in the tank. The delivery line to the plant passes through a covered tunnel 4½ ft. square and about 80 ft. long from tank to plant. The elevation of the storage tank is such that the oil flows by gravity to the small pumps, making delivery to the fuel tank of each engine. These tanks are equipped with gage glasses and are calibrated so that volumetric measurement of the oil used may be made.

The exhaust gases from the engines are delivered into reinforced-concrete muffler chambers, one for each engine, located outside the building to avoid setting up vibration in the structure, with the top just above the ground. There is no connection between the two chambers. Cast-iron riser pipes discharge the gases above the roof level. These pipes and the top of one of the chambers are visible in Fig. 4.

Owing to its great size the construction of the concrete oil reservoir may be of interest. It is 66 ft. in diameter and 20 ft. deep, being embedded in the ground so that the top barely rises above the surface. The top of the tank is now covered with earth about two feet deep and sodded to insulate the tank from the heat of summer and the cold of winter and to lessen the fire hazard. The vertical walls of the tank, which are supported by hook reinforcing, and the floor are 12 in. thick.

To provide for expansion and contraction, the vertical wall was built up in three sections, each being poured separately and continuously. At the three joints are diaphragms of 16-gage copper, 15 in. wide, which are placed vertically and embedded in the concrete of the adjoining sections. At the center of each diaphragm is a 1½-in. bellows to permit relative movement between adjoining sections, and at the same time stop any leakage from the tanks. The diaphragm is

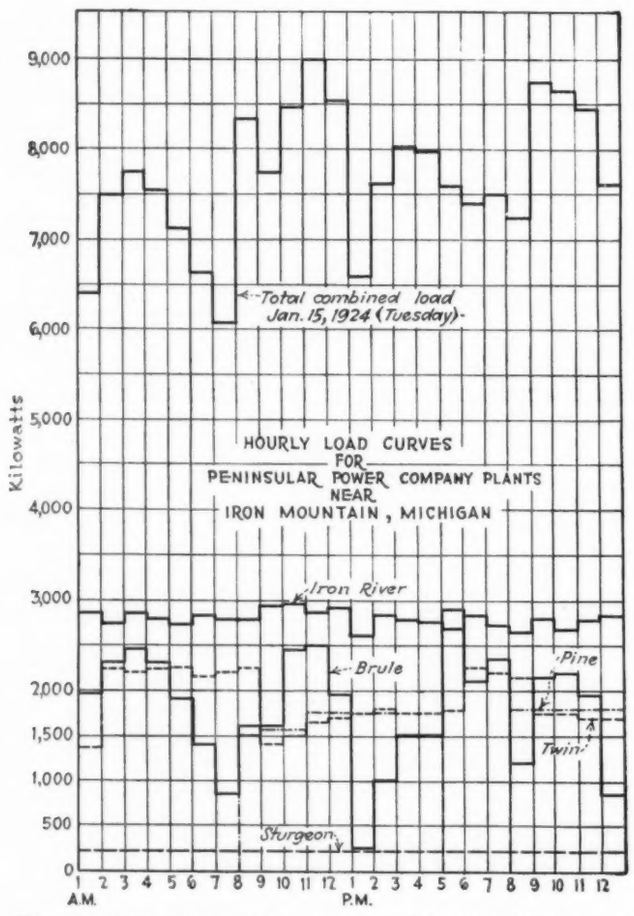


Fig. 2—Typical week-day loads on the individual plants and combined load of system

secured by vertical rods on either side of the joint, while at the base the vertical copper is soldered to horizontal base copper. The joints are probably the weakest points in the construction, so that if cracks develop, they should appear at these locations. The same type of joint has been used around the juncture of the wall and the floor. This type of construction has been used with success in other installations.

The floor of the tank is covered with a grid of piping with 6-in inlet and outlet and 650 lin.ft. of 3-in. distributing pipe. Cooling water from the Diesel engines at a temperature approximating 160 deg. F. is circulated through the pipes to keep the oil at the proper temperature for handling during the colder months. Provision is made also so that steam may be turned into these pipes in case the water supply is inadequate. In the space above the oil the top of the tank is provided with a system of drilled pipes through which steam or fire foam may be admitted to smother any fire that may develop in the tank.

TABLE I—ITEMIZED COST OF DIESEL POWER PLANT

Undistributed Costs	
General superintendence	$2,812.88
Preliminary work, surveys, etc.	768.80
Office labor and supplies	1,206.65
Maintenance of teams	305.09
Miscellaneous supplies	933.05
Lumber and freight	5,588.08
	$11,614.55
Cost per kw. of generator capacity	$6.75
Diesel Power House	
Excavation and backfill	$1,903.81
Cement for building construction (2,988 sacks)	1,960.13
Gravel for building construction (600 yards)	1,072.70
Cement for machinery foundations (3,250 sacks)	2,132.00
Gravel for machinery foundations (655 yards)	1,171.07
Miscellaneous supplies	112.75
Brick, 178M	1,708.80
Roof tile	920.00
Steel sash and doors	1,078.02
Lintels and thresholds	678.08
Structural steel	8,150.07
Lumber	12,76.32
Roofing	440.00
Roof ventilators	111.20
Miscellaneous material	923.07
Pipe and metal work	769.70
Electric fixtures	436.28
Labor on forms	5,925.30
Labor for mixing and replacing concrete	3,002.90
Labor on other than forms and concrete	14,536.31
Labor for painting	424.75
Maintenance of equipment	80.00
Freight	2,072.35
	$50,825.61
Cost per kilowatt of generator capacity	$29.55
Oil Tank	
Excavation and backfill	$3,233.36
Cement (4,192 sacks)	2,749.95
Gravel (750 yards)	1,342.00
Reinforcing steel	3,575.69
Labor for forms	6,238.08
Labor for mixing and placing concrete	1,571.52
Maintenance of equipment	234.00
	$18,944.60
Cost per kilowatt of generator rating	$11.01
Cooling Pond and Pumping House	
Excavation and backfill (labor and supplies)	$3,278.00
Concrete:	
Cement, 3,440 sacks	2,491.23
Gravel, 691 yd.	1,235.30
Labor-forms, mixing and placing concrete	3,893.45
Reinforcing	1,084.44
Form lumber	996.95
Miscellaneous material and supplies	786.91
Maintenance of equipment	310.15
Superintendence	1,331.19
Piping:	
Material (pipe and fittings)	2,686.82
Labor	658.50
Miscellaneous	353.75
	$19,106.69
Cost per kw. of generator rating	$11.11
Machinery and Equipment	
2 Nordberg Diesel engines	$161,525.00
2 Westinghouse generators	15,079.00
1 Crane, hand-power traveling, 15 ton	1,901.16
Motors, etc.	2,352.51
Piping, etc.	5,991.46
Freight on equipment	3,090.45
Electrical switchboard	5,325.00
Electrical wiring, conduit, etc.	2,728.04
Freight on electrical equipment	474.53
Installation of engines	8,772.26
Installation of generators	224.81
Installation of electrical auxiliaries and wiring	2,658.96
Installation of oil-handling equipment	3,045.70
Oil pumps	896.76
Oil piping	4,023.07
Miscellaneous material	188.95
Welding gas	218.39
Freight	299.00
4 Centrifugal pumping units for cooling pond	3,637.00
	$222,432.05
Cost per kw. of generator rating	$129.32
Total cost of plant	$322,923.50

Coming from the Iron River the water supply for the plant always had been bad, as the water contains a large amount of iron ore in suspension and considerable sewage from towns along the stream. Through

the liberal use of compounds and frequent cleaning this water had been used in the boilers of the steam plant, but owing to the difficulty of cleaning the jacket spaces in the Diesel engines, purification was considered desirable. For this purpose, a cooling pond 73 ft. wide and 168 ft. long, with walls 4 ft. deep, was built to contain 3 ft. of water. A small pumphouse at the river provided with a strainer unit will supply the makeup, estimated at 10 per cent, that will be required to give a continuous supply.

The river water is passed through a triple strainer and over a weir into the pond and must pass at low velocity through the 168 ft. of tank length before it can be drawn out at the opposite end for use in either the steam or Diesel-engine plants. In this length of travel it is expected that the iron ore and other suspended matter will settle out, and with a third strainer at the outlet to catch the leaves or trash that may blow into the pond, satisfactory water for either plant should be available. Distributed over the bottom of the tank are eight sumps provided with drain pipes through which the sludge can be washed out and returned to the river below the inlet. Under maximum conditions about 4,000 gal. per min. will be taken from the pond, but present requirements probably will not exceed 3,000 gal. per min. The water is returned to the pond through 20 spray groups of four 2-in. nozzles each.

Table I will be of interest, as it gives an itemized account of the cost of the new plant, the total amounting to $187.74 per kilowatt of generating capacity. This figure, however, includes the cooling pond and pumphouse and the pumping equipment used in this connection, which should be divided proportionately between the two plants and thus reduce slightly the total cost of the Diesel-engine plant. Looking over this table, it will be seen that the undistributed costs amount to

TABLE II—RECORD OF DIESEL ENGINE OPERATION

Week of 1924 Ending	Output, Kw.-Hr.	Peak, Kw.	Hours Run	Load Factor, per Cent	Fuel Oil Used, Gal.	Kw.-Hr. per Gal.
			1 Engine			
Feb. 9	106,075	1,000	137	81	9,650	10.99
Feb. 16	111,175	1,000	154	72	10,105	11.00
Feb. 23	67,025	1,000	85	79	6,000	11.17
Mar. 1	141,675	1,000	168	84	12,475	11.36
Mar. 8	129,875	1,000	155	84	11,800	11.01
			2 Engines			
Mar. 15	215,050	1,900	168	67	19,250	11.17
Mar. 22	247,625	1,900	168	77	23,250	10.65
Mar. 29	234,975	1,900	168	74	21,875	10.74
Apr. 5	155,900	1,900	120	68	14,375	10.84
Total	1,409,375		1,323		128,780	

Average kw.-hr. per gal. = 10.944.
Average lb. of oil per kw.-hr. = 0.676.
Oil, Sinclair distillate, 19,500 B.t.u. per lb.; gravity, 24 to 26 deg. Baumé; 7.4 lb. per gal.; cost delivered 5.85c. per gal.

$6.75 per kilowatt, and the unit costs for the items going to make up the plant in the order given in the table are as follows: Building, $29.55; oil tank, $11.01; cooling pond and pumphouse, $11.11; machinery and equipment, including the pumping and the strainer units for the cooling pond, $129.32. Adding the various totals in the table, the final cost of the plant was $322,923.50.

Nine weeks of operating data are presented in Table II. For five weeks one engine was in operation, and for the rest of the period two engines were used. The load factor, as will be seen, ranged from 68 to 84 per cent and the kilowatt-hours obtained per gallon of oil from 10.65 to 11.36. The average for the nine weeks is 10.94 kw.-hr. per gallon, which reduces to 0.676 lb. of oil per kilowatt-hour. The particular oil used was Sinclair distillate of 24 to 26 Baumé gravity zero cold test, and averaging approximately 19,500 B.t.u. per lb. The oil was specified to contain less than one-half of one per cent of sulphur and not over 3 per cent sediment. Of this oil there are 7.4 lb. per gal. The cost, as previously stated, was 2c. per gal. at the source and the freight 3.85c. per gal., making the delivered cost 5.85c., which reduces to an average fuel cost per kilowatt-hour of 0.534c.

Considering the condition, the results are excellent, and operation from the beginning is reported as satis-

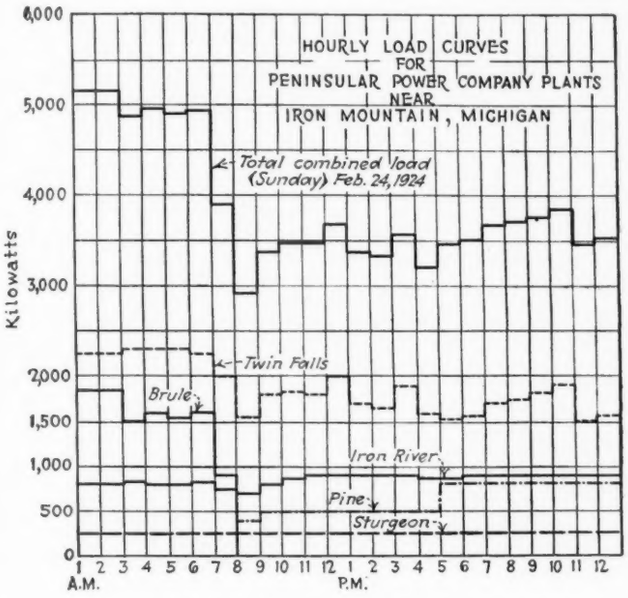


Fig. 3—Typical Sunday loads

factory. No difficulties except those incidental to the starting of a plant of the type and size have been experienced. Owing to the muffler chambers the noise from the exhaust is not objectionable. The only annoyance of any moment is that experienced from the intake to the scavenging pump. During the suction stroke sufficient vibration is imparted to the building to make the windows rattle. Work is now under way to improve this condition.

Daniel W. Mead–Charles V. Seastone, consulting engineers, of Madison, Wis., were in charge of the design and construction of the new plant.

THE PRINCIPAL EQUIPMENT OF DIESEL ENGINE PLANT OF PENINSULAR POWER CO.

Diesel Engines—Nordberg Carels—1,250 b.hp.—vertical, 180 r.p.m., two-stroke-cycle type	Nordberg Mfg. Co.
Generators—1,075 kva., 860 kw., at 80 per cent power factor, 60 cycle, 6,600-volt, engine type, 180 r.p.m.	Westinghouse Elec. & Mfg. Co.
Separate air-charging compressor—gasoline engine drive, belted	Nordberg Mfg. Co.
2 Circulating cooling water pumps, 3-in. centrifugal, 300 g.p.m. each, motor driven	Goulds Mfg. Co.
1 Tank heating pump, 3-in. centrifugal	Allis-Chalmers Mfg. Co.
2 Spray-pond pumps, 12-in. 4,000 g.p.m., motor driven	Allis-Chalmers Mfg. Co.
2 Makeup pumps, 5-in., 500 g.p.m., motor driven	Allis-Chalmers Mfg. Co.
Spray-pond equipment and strainer, 20 spray groups of four 2-in. nozzles per group	E. B. Badger & Sons Co.
Cast-iron pipe	U. S. Cast Iron Pipe Co.
Fabricated piping	Crane Co.
Pyrobar gypsum blocks, roof Diesel plant	U. S. Gypsum Co.
Steel work	Marinette Boiler Works
Platforms and walkways, Irving subway grating	Irving Iron Works
Portland cement	Universal Portland Cement Co.
Lumber	Phoenix Lumber & Supply Co
Roof, Barrett specification	Northern Corrugating Co.
Special coils for oil-car heating	Wisconsin Foundry & Machine Co.
Reinforcing steel	Kalman Steel Co.
Common brick	Illinois Brick Co.

The Industrial Power Plant

Its Possibilities and Place in Our Economic Structure

By EGBERT DOUGLAS*

POWER, in most industries, is relatively a small item; it seldom reaches 5 per cent in the cost of the finished product, and many executives have on this account looked upon their power plants as unimportant so far as presenting opportunities for reducing costs. Such a view is natural because its ramifications are technical, and technical things are uninteresting to many executives. They think in terms of costs of the particular things manufactured. On the other hand, the power-plant engineer has been left pretty much to himself and has but meager contact with the other departmental heads. This has divorced the industrial power plant from the rest of the organization to such an extent that it has come to be looked upon more or less as a nuisance or a necessary evil. The cost of operating it is known as to the total dollars outlay per month or year, but whether these costs are high or low is seldom known. Few records are available outside of the money spent.

WHEN compared to the cost of the finished product, power has been such a small item that economy in its production has been looked upon as unimportant. So much so that to get the power the easiest was considered the best way; therefore, much power has been purchased without reference to what it could be produced for along with another necessity, called heat.

The writer has examined hundreds of industrial power plants, and the only records available of their operations were the paid invoices in the general offices covering coal and purchases of other materials that went into them. The major item of expense is coal, and this is usually purchased without reference to its qualities, except its price per ton. It is dumped into the boiler room and the firemen presented with shovels and told to burn it. What this coal produces in steam and converts into power often appears to be of little consequence because nothing is measured or weighed, not even the coal itself, except car weights as it comes in. What other line of raw materials is put through in such a slipshod manner?

The reason for this is plain. Coal has, until the recent past, been relatively cheap, and heat and power have been measured in terms of costs of the finished product or not measured at all, and when measured this way, the product of the power plant has presented rather an insignificant figure. For example, in a certain shoe factory it may cost three dollars to make a pair of good shoes, and the power part of the shoes may not, and probably does not, amount to fifteen cents. The executive in such a factory naturally thinks in terms of shoe costs. He would, perhaps, argue that if he reduced the operating expenses of his power plant 25 per cent, it would reduce the cost of a pair of shoes less than a nickel, and thus the matter would end. Yet in this same plant it might easily be possible to reduce the fuel bill several thousand dollars a year if the things the fuel directly produced—heat, steam, light and power—were consistently measured and analyzed.

The low thermal efficiency of steam power plants has been overlooked, and in the districts afflicted with long and severe heating seasons can be found numerous boiler plants used only for heating purposes, and here the steam is blown into the heating systems through reducing valves and its mechanical energy wasted. With the rapid development of electricity most persons have come to think of nothing but power when coal is mentioned. The result is that millions of tons of coal are wasted through neglect of the heating problem. Cheap kilowatt-hours and the physiological effect of size and the large power stations producing electricity, have led many astray to such an extent that the heating problems, and their inseparable relation to steam power, have almost escaped attention in the industrial power plants.

Low cost of power is one thing, but cheap B.t.u. is more important. When one stops to consider that the best central power station performance so far has been to put a kilowatt-hour on the switchboard with a heat expenditure of approximately 17,000 B.t.u., and then considers that a kilowatt-hour contains the equivalent of only 3,416 B.t.u., a calm realization comes of the importance of conserving the effective B.t.u. contained in the coal.

Modern manufacturing conditions with more and more regulation for safety and comfort of workers have brought about increased floor areas for a given amount of power employed. Demands for more daylight in working spaces have greatly increased the amount of glass used in factory buildings. This has brought a much needed supply of sunlight, but it has also added materially to the heating demands, until now the boiler plants in many industries completely overshadow the power requirements.

Yet much more attention is given to the power than is attached to the heating. To illustrate, the author has in mind an industrial establishment with upward of fifteen acres of inclosed floor space, which has to be heated eight months out of every twelve, or 66 per cent of the time. In this space, aggregating over six million cubic feet, is used about 1,250,000 kw.-hr. in a year, and for every heat unit (B.t.u.) used for power and light, about fifteen heat units are required for heat. This is a fair sample of a moderate-sized manufacturing establishment. In this factory the boiler capacity required for providing the necessary heat is about three times that required to produce the power.

A more exaggerated case of the lopsided boiler loading of the problem between heat and power is one where a group of buildings contains over 32 million cubic feet of space, and about 1,500,000 kw.-hr. is used for light and power. To heat this space over 20,000 tons of coal is required every twelve months. The power is all purchased, and for each kilowatt-hour that is consumed, more than 27 lb. of coal is burned to supply the heat, in space where the electricity is consumed.

One can get a better understanding of proportion

*Cahill & Douglas, Consulting Engineers, Milwaukee, Wisconsin.

when stopping to consider that a kilowatt-hour can be produced in an ordinary non-condensing steam plant easily with 5 lb. of fair coal, and from the exhaust steam therefrom can be recovered, also easily, 80 per cent of the heat in the steam.

The Disease Is Common to Most Industries

In the paper industry it has become a well-defined policy to measure, or compare, the coal by the amount of paper produced. Tons of paper and tons of coal have been considered sufficient. The distance from the finishing rolls on the paper machines to the furnaces under the boilers has been lost sight of, and the many things that can happen in between, are not realized. The paper mills of the country burn enormous quantities of coal; most of it is used for heat.

Henry Ford in his Highland Park Plant in Detroit does not measure the performance of his boiler room in that magnificant factory by the number of "tin lizzies" that pass down the runways. But he knows what coal is required to produce a thousand pounds of steam and insists that the boiler plant come somewhere near this figure. He also knows how much steam should reasonably be required to produce a kilowatt-hour of electrical energy, and he knows what he can do with the exhaust steam from the steam prime movers that grind it out.

In the woodworking plants, where wood waste has been the principal fuel, little attention is paid to the manner in which this is burned, and much coal is now required for steam making owing to the closer cutting of all woods. If greater care were exercised in the burning of the wood waste, it is quite within the range of possibility that no coal would be required in many of these plants at all.

In the state in which the author lives milk condenseries are among the major industries and they are among the largest consumers of coal. Condensing milk is done by evaporating a large part of the water therefrom in vacuum pans under about twenty inches of vacuum. The boiling point at this vacuum is less than 165 deg. There is a well-defined notion among many executives in this industry that this cannot be done with exhaust steam, which has, at atmospheric pressure, a temperature of 212 deg. F. This notion has caused many of these industries to purchose their power, whereas it could all be made as byproduct of the evaporating process and all the exhaust steam from the power-making engines could be used in the vacuum pans as a heating medium. A plant of this kind has recently been changed over from purchased power to its own generating equipment and a net saving of more than $12,000 a year accomplished, with an investment of about $15,000 in generating equipment.

Power Should Be Obtained as Byproduct of Heat

In our industries the major part of our coal is required for heating purposes, and much of the power can, and should, be obtained as a byproduct of the heat. The possibilities in this direction can best be realized by looking at the various losses in a steam power plant. In an ordinary boiler plant it is readily possible to get 65 or even 70 per cent of the heat in the coal into the steam. Now we have, say, 70 per cent of the heat in the coal in the steam, and we pass this steam through an engine to make power. What happens? The engine runs and out comes the exhaust, puff, puff, puff, and in these puffs will be found from 80 to 85 per cent at least of all the heat that left the boiler room a few seconds before.

The thing for the industrial executive to do is first make up his mind that his power and steam problems are no different from anybody else's and that they are governed by the same fundamental truths long since amply proved.

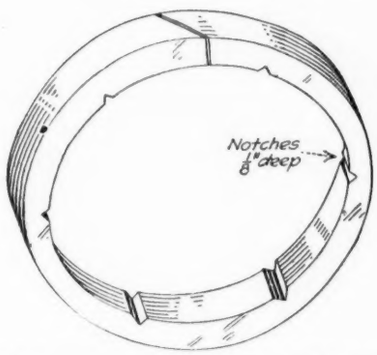
The next thing for him to realize is that his steam boiler plant is a manufacturing outfit all by itself, and its real job is to produce steam with the least amount of coal and at the lowest consistent cost. And the next thing is, after the steam has been produced to see that it is applied in such manner that the least amount of it will be used in getting the greatest amount of power, and then, finally, after the power has been made, see that no heat from the exhaust is unduly wasted.

When all our industries are down to this basis, the power plants will all look better, and the engineers operating them will know more and get better salaries. The coal bills will be about one-half what they are now, and the executives will wonder why they didn't do it before.

Notches in Packing Reduce Wear and Scoring of Shaft When Gritty Substances Are Being Pumped

By S. H. Samuels

When pumping water containing a high percentage of sand or other gritty substances with a centrifugal pump, as in the case of dredging operations, it is difficult to keep the shaft glands sufficiently tight to prevent air being drawn into the pump even though water



Notches prevent wear on packing and scoring of shaft

is continually run into the gland. This is because the sand and grit, finding their way into the gland, rapidly wear away the hydraulic packing inside the "lantern" ring and also wear the shaft to a certain extent.

If the rings of packing are notched $\frac{1}{8}$ to $\frac{3}{16}$ in. deep in six or eight places on the side next to the shaft, as illustrated, it will be found that the packing will last much longer and the shaft will remain unscored.

My experiences have proved this method to be most effective, and I have used it in dredging operations where it was necessary to pack the pump every shift. After this simple alteration was made in the rings of packing, the pump would run at least a week with a renewing of only the outer packing. This is attributed to the fact that the V-notches allow the circulating water in the gland to wash the sand and grit into the pump and thereby restrict their passage along the shaft.

Pipe Joints for High Pressures and Temperatures

THE Detroit Edison Company has utilized a type of joint, shown in Fig. 1, at the Marysville and Trenton Channel plants, designed for 400-lb. 750-deg. F. service. It will be seen that this is the familiar Van Stone raised-face type, the drawing representing to scale a 4-in. nominal pipe size, with "phonograph finish." The Detroit Edison standards do not allow threaded flanges in 4-in. pipe sizes or larger. The Van Stone principle, developed many years ago, eliminates the necessity for screwed connections between pipe and flange. Ends of the adjoining pipes are here rolled out at right angles, forming flanges solid with the pipes, and loose collars assembled as shown, bolt together so as to hold the pipe ends rigidly together. These joints may be machined if desired for raised face, as usually is the case as well as tongue and groove, or any other design of contacting surfaces. Reinforcing rings ordinarily are welded to the flanges before machining, so that the thickness of metal when finished, will not be less than that of the pipe itself.

The clearances and curvatures of the bolted collars in the figure are arranged so as to give maximum pressure in the extreme outside region of the joint. This is for the purpose of concentrating the compressive force around the outside edge of the flanges so that the tendency will be to produce a wedge-shaped gasket space, with the greatest width of the section toward the interior of the pipe. Any movement of the gasket, therefore, due to a tendency to blow out, will tend to pack it more tightly in the wedge-shaped space. Dimensions correspond closely to the 600-lb. A.E.S.C. tentative standards, published in the Dec. 4, 1923, and March 18, 1924, issues.

The "phonograph finish," or roughening of the raised faces, gives an additional means of confining the gasket, which is one of long-fibered asbestos. Thus, the advantages of convenience in erecting and replacing the raised-type face of joint is combined with a greater degree of relative steam tightness than the raised face otherwise possesses. This roughening is accomplished on each face by cutting grooves about $\frac{1}{64}$ in. deep with a round-nose tool. These may be in the form of a spiral or else a series of circles eccentric with the pipe. The grooves are spaced about 32 to the inch. This joint has been thoroughly successful at the Marysville plant, after an extensive test in 300-lb. 700-deg. service. The brief trial at the Trenton Channel Station with 420-lb. 725-deg. steam, although satisfactory to date, has not been sufficient for passing judgment.

The usual raised-face joint, Fig. 3, which fulfills the requirements of moderate pressures so well, is less able to withstand high pressure than the tongue-and-groove, Fig. 4, or the recessed face, Fig. 5. Tests reported Nov. 17, 1922, to the N.E.L.A. Prime Movers Committee showed that with the same gasket pressures and materials it was possible to blow the gasket out of a raised-faced pipe joint at a lower pressure than would cause a leak in the tongue-and-groove type. There was no instance in these tests where the former would withstand one-half the pressure of the latter under similar conditions. Gasket pressures in the neighborhood of ten to twelve times the steam pressures have been highly successful in process work, where temperatures and pressures relatively are higher than those of the present maximum steam conditions.

Experience with gasket materials at maximum steam temperatures and pressures has been quite conflicting. Asbestos may solve the problem very well at one installation, yet in another of similar conditions metallic gaskets would be preferred. In process work with temperature around 800 to 900 deg., narrow metallic rings at high gasket pressures have frequently found favor.

The joint in Fig. 5 may be satisfactory as regards relative leakage, but shares with the tongue-and-groove joint the disadvantage of difficulty in erecting and replacing. In each case the pipe line must be separated sufficiently at the joint, so that the projecting portions of one flange may be withdrawn from the recesses in the other.

The Sargol pipe joint, Figs. 2 and 8, has been developed for the purpose of securing a greater degree of tightness than the ordinary raised-face Van Stone joint allows. It will be seen that these joints are very similar to Fig. 1. Provision, however, is made for welding both of the pipe ends together so that a gasket is not required. In replacing such joints, chipping and welding are necessary procedures. One of the first stations to operate in the neighborhood of 700 deg. 300 lb., was the Springdale plant of the West Penn Power Co., which adopted the Sargol type. Where special adjusting or replacement of pipe sections was necessary, a gasket could be placed between the flanges so that welding could then be postponed until a convenient opportunity arrived.

Welded-type joints have not so far been utilized to any noticeable extent for maximum steam conditions, although for the fastening of nozzles and miscellaneous work, welding occupies an important position. The joint, as in Fig. 6, should be sufficient for 4-in. pipe at 750-deg. 400-lb. service except for the fact that it lacks the rigidity of a bolted connection, and therefore, under conditions imposed by pipe flexure, abnormal circumstances, etc., the reinforced weld, Fig. 7, is preferable, which weighs and costs less than a bolted type. These are of interest as a future possibility, when temperatures and pressures have become greatly increased and bolted joints are at a greater disadvantage.

Experience with small pipes in the neighborhood of 1 or 2 in. indicates that for high pressures, raised-face flanges screwed to the pipe and fastened by an additional welding around the threads to prevent leaks, give satisfactory service.

Six hundred pound pressure will be utilized at the Philo station of the Ohio Power Co. The joints here employed are of the Sargol type, as in Fig. 8. Each 1-in. bolt is turned to approximately root diameter, so that if any stretching occurs, it would be equalized over the entire length of the shank, and thus reduce the tendency to break in the thread. This corresponds to the A.E.S.C. standard for 900 lb. being drawn to scale for 4-in. nominal size pipe.

Types of Joints for High Pressure and Temperature Service

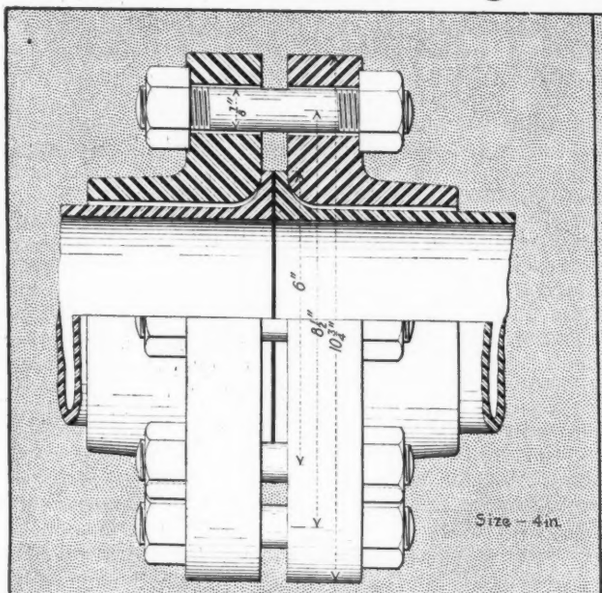


FIG. 1 — DETROIT EDISON, VAN STONE TYPE WITH "PHONOGRAPH FINISH"

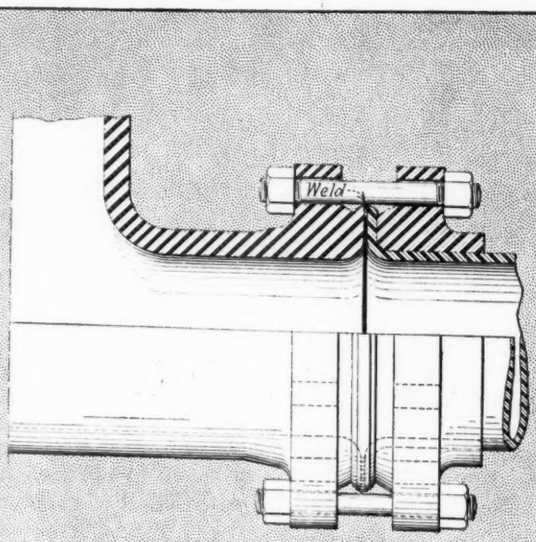


FIG. 2 — GASKET IN SARGOL JOINT ALLOWS WELDING WHEN CONVENIENT

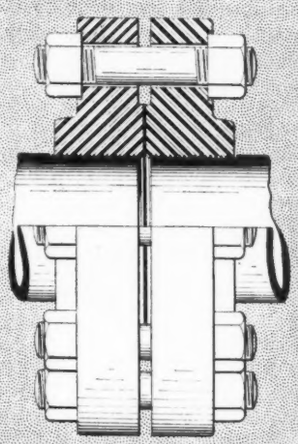


FIG. 3 — RAISED FACE JOINT

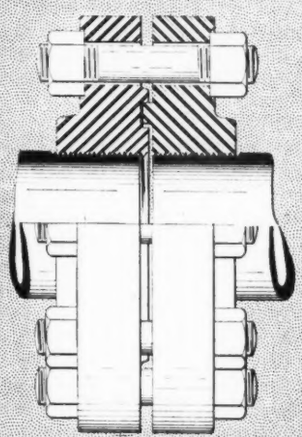


FIG. 4 — TONGUE AND GROOVE

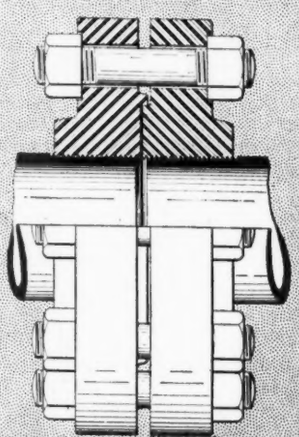


FIG. 5 — RECESSED FACE OR SPIGOT JOINT

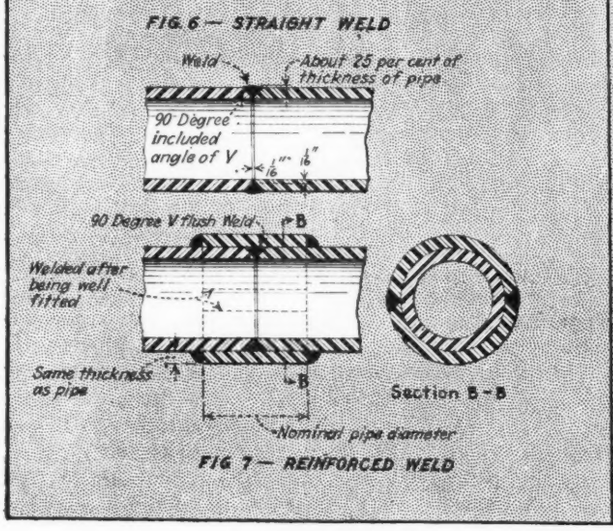


FIG. 6 — STRAIGHT WELD

FIG. 7 — REINFORCED WELD

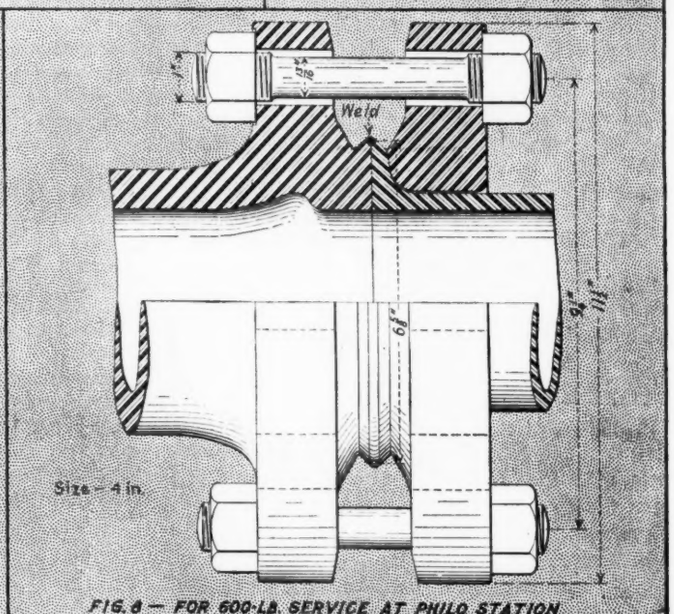


FIG. 8 — FOR 600-LB. SERVICE AT PHILO STATION

Tests To Make on Direct-Current Motors When Putting Them Into Service

Methods For Determining if the Connections Are Correct on Series, Shunt and Compound Motors Before Putting Them Into Service—How To Test the Polarity of the Series- and Shunt-Field Coils in Compound Motors

By CHARLES A. ARMSTRONG

AFTER a motor has been connected up, there are a number of things that should be done before starting, to insure the successful operation of the machine. It should be made certain that the machine is properly lubricated and that the oil rings are free to move. The latter should also be carefully checked after the motor has been started. Although the rings may

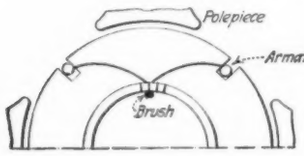


Fig. 1—Brush is opposite center of polepieces

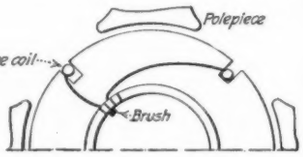


Fig. 2—Brush is midway between polepieces

appear to move freely when tried by hand, they may stick and fail to revolve with the shaft after the motor starts, owing to particles of dirt in the oil or on account of the rings being burred or bent.

In a direct-current machine the position of the brushes must be checked. On the modern machine this position is generally marked. Even when it is marked, it is always well to check the brush location by tracing the top lead from an armature coil in the neutral position to see if it comes to a commutator segment on which a brush is resting. On modern-type machines the brushes are generally located opposite the center of the main poles, in which case the armature coil leads are both the same length and are given the same throw, as in Fig. 1.

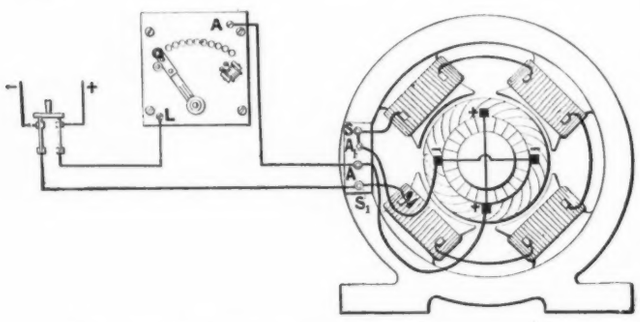


Fig. 3—Diagram of series-motor connections

Some of the older-type machines, which use a short and a long lead on the armature coils, have the brushes set opposite the neutral zone, as in Fig. 2. It should also be made sure that all connections are in good condition and tight and that there are no loose bolts or tools lying around that might be drawn or fall into the machine after starting.

After these details have been taken care of, starting of the machine may be considered. The connections of a series motor to a manual-type starting box, Fig. 3, are so simple that it would be almost impossible to make a mistake. In fact, the only mistake that could be made on the motor would be to connect the two line wires to either the armature or field terminals and then connect either the two field or the two armature terminals together. If the leads cannot be traced out conveniently from the inside of the machine to check the marking, the connections may be tested by disconnecting the lead to either the armature or field terminal and connecting a lamp in circuit, as in Fig. 4. After this is done, close the switch and bring the starting box over to the first point. If the lamp lights, it is known that a circuit is

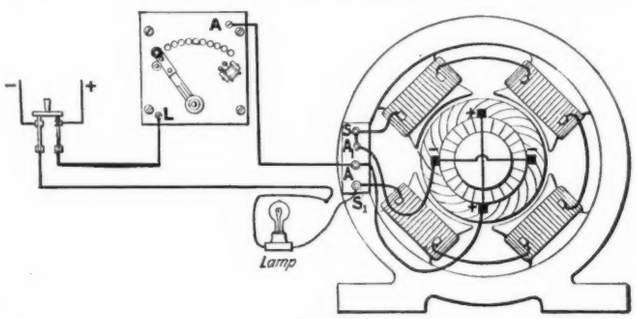


Fig. 4—Lamp connected in circuit to test connections of series motor

complete through the motor. However, this does not indicate that the motor is connected properly, for if the lamp were connected into one side of the field circuit as in the figure, the other field terminal might be connected to the starting box, in which case the armature terminals would be connected together with the jumper and cut out of circuit.

To determine if both the armature and the field coils are in circuit, open one end of the jumper between S and A_1, leaving the lamp in circuit as in Fig. 4, again close the switch and bring the starting-box arm up on the first point. In this case if the connections are correct the lamp will not light, since opening the connections between the armature and field should open the circuit through the motor. If the lamp does not light, the jumper may be touched to the terminal it was disconnected from to make sure the lamp will light.

When everything is found satisfactory, the switch can be opened, the connections made permanently, the motor started and the direction of rotation noted. If the armature turns in the wrong direction, it may be reversed by interchanging either the armature or field connection. For example, in Fig. 3, if the wire from the

starting box to the armature terminal A is put on A_1 and the end of the jumper on A_1 is connected to A, the direction of the current through the armature will be changed and the direction of rotation will be reversed. After the right direction of rotation has been obtained, the motor should be brought up to speed carefully to see that it does not spark excessively at the brushes or race. A series motor must be fully loaded or it will run at a speed above normal and if lightly loaded it will race.

With a shunt motor, Fig. 5, the connections are a little more complicated than for the series type, consequently there is greater opportunity for making mistakes when connecting the machine up. Before any shunt motor can operate satisfactorily, the field circuit must be complete and energized, and this part of the connections should be tested before attempting to start the motor. This can be done and the correctness of the connection checked at the same time by disconnecting the armature wire at the starting box and at the motor, as in Fig. 6, then closing the switch and placing the arm on the starting box upon the first contact. When the arm is allowed to fall back to the off position, a spark should be obtained when the circuit is broken. It is also a good idea to move the arm over to the no-voltage release coil and note if it is held. If the holding coil is operative, it indicates that the circuit is correct through the box and field coils. After this test is made and the field circuit is found complete, the armature circuit can be closed and starting the motor tried and brought up to speed slowly, preferably without load. However, in no case should starting of the motor be tried until it is known that the field circuit is complete.

It is quite general practice to test the field circuit by disconnecting the armature circuit at the starting box only. But if a mistake was made in connecting up the motor and the armature and line wires were interchanged, then with the armature wire disconnected at the starting box, the field circuit will be complete although the motor is connected wrong and it will race if an attempt is made to bring it up to speed. When the armature wire is disconnected at both the starting box and motor terminals, if a mistake is made in connecting up the machine, the field circuit cannot be completed with any but connections that will provide a field circuit when starting the motor. On small motors where all wires between the starting box and the motor are the same size, it is possible to cross the line and field wires. Under such a condition the field circuit will be complete with the armature wire disconnected, but with this connection the armature circuit will not be complete with all the connections made, therefore the motor will not start and no harm will be done by trying.

If the motor is an interpole machine, as in Fig. 5 and 6, the correct polarity of the interpoles can be tested by opening the shunt-field connection at the starting box and after carefully marking the position of the brushes, shifting them 4 or 5 segments and trying starting the motor. If the interpole polarity is correct, the armature will turn in the direction in which the brushes were shifted. Opposite direction of rotation would be an indication that the polarity of the interpoles is wrong, and the direction of the current should be reversed through them. After the correct polarity has been obtained, the brushes can be put back into the correct position, the shunt-field connections made and the motor started.

A compound motor has both a series and a shunt winding on the same polepieces, as in Fig. 7, and in most general-purpose motors these two windings have the same polarity; therefore, in addition to determining that the shunt-field circuit is complete, it is also necessary to check the polarity of the series- and shunt-field coils. When the shunt- and series-field coils have opposite polarity, it may produce only a slight increase in speed from no load to full load, but in most cases it will cause one of the following effects, depending upon the relation between the shunt- and series-field ampere-turns:

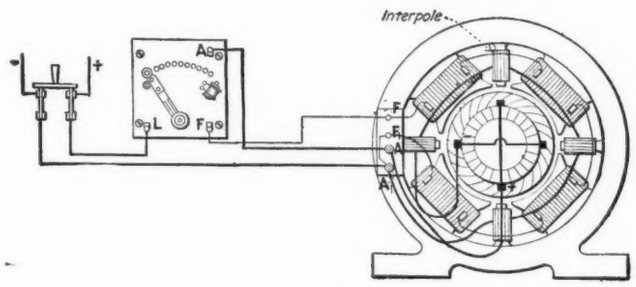


Fig. 5—Diagram of shunt-motor connections

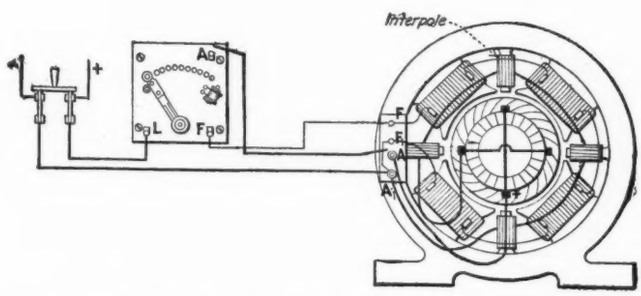


Fig. 6—Armature connections open to test field circuit of shunt motor

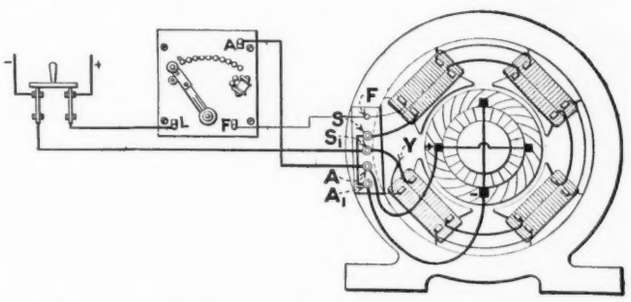


Fig. 7—Diagram of compound-motor connections

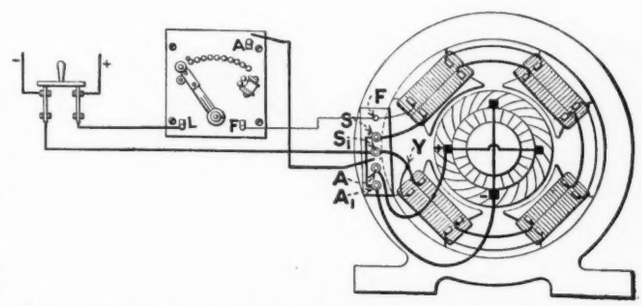


Fig 8—Armature connections open to test shunt-field circuit of compound motor

1. The motor may start and operate satisfactorily under no load. When load is applied, it may suddenly increase in speed and spark badly at the brushes, causing the fuses to blow, or trip the circuit breaker.

2. The motor may decrease in speed to the point where the fuses will blow and, if not properly fused, may stop, reverse and run in the opposite direction. This will be accompanied by severe sparking at the brushes.

3. The motor may start in one direction, and when the starting resistance is partly cut out, stop, reverse and run in the opposite direction.

4. The motor may fail to start, the armature usually making slight effort to turn in one direction and then in the other.

5. If the series-field coils are of the proper proportions, it will give the motor practically a constant speed

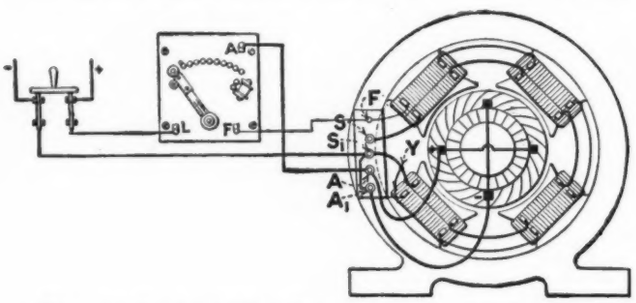


Fig. 9—Series-field coils cut out of circuit to test polarity of shunt coils

from no load to full load. This condition is seldom if ever found except in motors that are designed to accomplish this purpose.

After the motor has been connected up, the shunt-field circuit and connections should be tested by disconnecting the armature circuit at both the starting box and motor, as in Fig. 8, then making the test as for a shunt motor. When it has been determined that the shunt-field is energized, then test for the polarity of the shunt- and series-field coils. This may be done by first opening the connection between the series-field terminals and the armature and connecting the latter directly to the line wire as in Fig. 9 and trying to start the motor as a shunt machine. It is a good idea to bring the motor up to full speed on this connection and get it operating satisfactorily without load. After this has been accomplished, the direction of rotation is noted and the motor shut down. The series fields are again connected in circuit and the shunt-field circuit opened and the motor started again. If the series-field coils have the same polarity as the shunt, the armature will now turn in the same direction as before. A reverse direction would indicate that the polarity of the series field was opposite to that of the shunt and either one must be changed. Which one must have the direction of the current reversed through it will depend upon which gives the correct direction of rotation. Changing the direction of the current through the field winding that gives the wrong direction will not only correct the polarity of the field coils, but also the direction of rotation will be right. Where the polarity of the field coils is correct and it becomes necessary to reverse the direction of the motor's rotation, this can best be done by changing the direction of the current through the armature. If the motor has interpoles, their polarity can be tested as suggested for the shunt motor. Where one shunt and one series field lead are tied together within the motor, as at *Y*, in the figures, it will generally be found that the polarity of the field coils is correct.

If the foregoing instructions are followed, there should be little trouble in getting a normal direct-current motor into service without injuring the machine and at the same time being sure that the connections are correct. One thing should be remembered—whenever any change is made in the connection, the motor should always be left connected in a normal condition, such as indicated in Figs. 3, 6, and 7 for the series, shunt and compound motors respectively. Any other grouping of the connections will prevent the motor from operating satisfactorily.

Estimating the Temperature of Steam

Frequently, the pressure of saturated steam is known and it is desired to find the temperature in order, for example, to compute the radiation losses from steam-heated surfaces. Again, it is sometimes necessary to get the steam pressure with the aid of a thermometer. Either pressure or temperature having been found, the other can be read directly from the steam tables. Sometimes, however, no tables are at hand. Where a rough estimate will suffice, the following stunt will be found convenient:

Set down two columns of figures as shown. Note that the column *T* (temperature, deg. F.) starts at 250 and increases 50 at a time up to 400. The column *P* (pressure, pounds per square inch absolute) starts with 32 and doubles each time. This table can easily be carried in the head and "counted off" when needed. The third column is introduced to show the amount of error. The table should not be extended beyond the limits shown.

In view of the crudity of this method any attempts at close interpolation, etc., are a waste of time. It should merely be used as a guide to "scientific guessing" when no tables are at hand.

RELATION OF STEAM PRESSURES AND TEMPERATURES

T	*P*	Actual Pressure
250	32	29.8
300	64	67.0
350	128	134.6
400	256	247.1

Study of this table reveals some interesting things about the way the temperature of steam changes with the pressure. When the temperatures increase in an arithmetical series, the pressures go up almost in a geometrical series. The former is a series of numbers increasing by constant steps, while in the geometric series each number is obtained by multiplying the one before by the same constant. In this case the temperatures increase by steps of 50 deg., while each figure in the pressure column is double that which precedes it.

An example or two will show the application. It is desired to find the steam pressure in a line where no gage can be connected. A thermometer is tied against the main and heavily lagged to prevent cooling. The reading is 270 deg. F. The pressure is probably around 40 lb. absolute, or 25 lb. gage. A temperature of 385 deg. would indicate a pressure in the neighborhood of 200 lb. gage.

Suppose we wish to estimate the temperature of 150-lb. (gage) steam with 100-deg. superheat. The saturated temperature is evidently around 370 deg. F. and the total temperature around 470 degrees.

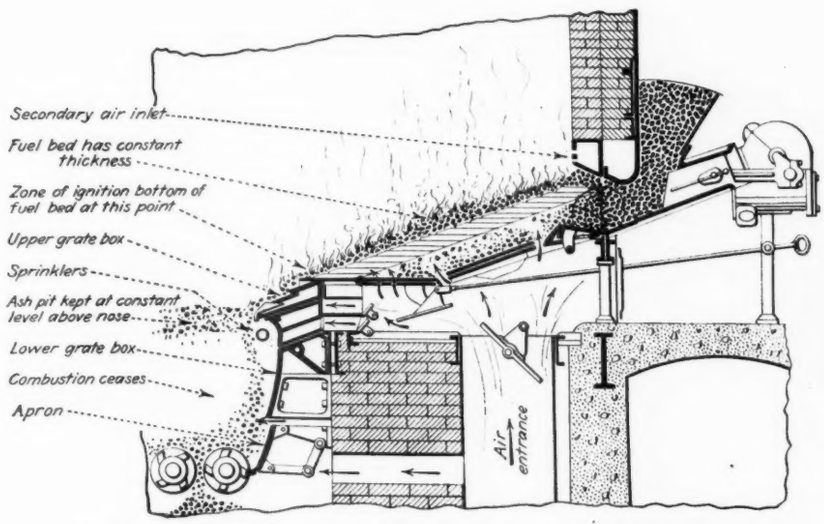
How To Regulate Underfeed Stokers

Practical Points on Reducing Combustible in the Ash, Balancing Stack Loss Against Ashpit Loss, Proper Speed for Clinker Grinders and Other Conditions Bearing on Efficiency of Combustion

By J. E. RICHARDSON

THE problem in stoker operation is to reduce the combustible in the refuse to the lowest value possible while using the least possible amount of excess air. In an underfeed stoker, as in the figure, the top surface of the fuel bed is at the ignition temperature and the coal is fed upward to the fuel bed from the retort underneath. In addition to the upward movement of the fuel there is also a slow movement toward the ashpit or discharge end of the stoker. As the coal on the surface burns, more is brought to a position above the tuyeres owing to the downward slope of the tuyeres and the horizontal movement of the coal in the retorts.

In the ideal case the fuel bed remains at a constant thickness above the tops of the tuyeres during its travel from the point of entrance to the point of discharge from the underfeed section. The zone of ignition extends down to the lower end of the fuel bed. There still remains a considerable amount of coked fuel that must be burned. In some stokers an overfeed section of grates is provided for the burning of this coke. On other stokers the burning of the remaining coke must be done entirely in the clinker pit or on the dump grates. Where the overfeed grates are provided, the thickness of the bed of coke is reduced due to combustion before it discharges to the clinker pit or dump grates.



Careful manipulation is required to burn coked fuel efficiently below the underfeed section

The mixture of ash and coke in the ashpit moves slowly downward, and additional coke is discharged on top of the pit section. Air is usually supplied to this ashpit section. As the coke and ash move downward, combustion continues to take place until the percentage of coke remaining is so small that ignition can no longer be maintained, provided that the mixture is not quenched with water or discharged from the pit before this point is reached.

Uneven Coke Burning and Excess Air

There will be some places in the ashpit where the coke is burned out before it is in others due to uneven burning across the width of the fuel bed. The gas or air passing through such places where the combustible is burned out, is very rich in oxygen and, unless it can be used to burn some of the combustible gases rising from the fuel bed proper, will be carried through the boiler as excess air. In order to minimize the amount of ashpit surface where the air can get through without having its oxygen converted into carbon dioxide, it is necessary to speed up the stoker so as to cause the refuse at other parts of this pit to pass below the zone where combustion can take place before the percentage of combustible is sufficiently reduced.

Because of these conditions in the discharge end of the stoker, it is always the case that either one of the ashpit or stack losses could be somewhat reduced at a resultant sacrifice in the other. The problem of the stoker operator is to so regulate the coal feed as to keep a proper balance between these two losses in order that their sum may always be a minimum.

The oxygen in the air passing through the main part of the fuel bed is not only converted to CO_2, but this CO_2 is largely reduced to CO. Secondary air must be supplied on top of the fuel bed for the combustion of this CO in order to minimize any loss from incomplete combustion. In some stokers the air for this purpose is admitted through holes in the side and front walls.

It is always advantageous to use to the fullest extent the uncombined oxygen coming from the clinker pit for the burning of the combustible gases arising from the fuel bed. However, owing to the difficulty in securing proper mixing of the gas with the air, unless the furnace volume is large, the gas may reach the boiler surfaces before combustion is complete and then be cooled somewhat.

Secondary Air Reduces Incomplete Combustion

Since this condition is likely to result in a considerable combustible gas loss, it will be advisable to admit air enough to insure a complete mixture of the gases before reaching the boiler surfaces even though this does result in somewhat increased stack losses due to more excess air. Practice in present stokers is to admit this air above the fuel bed, preferably at the

front wall of the furnace. The amount of air admitted through holes in the front and side walls for this purpose should, however, be always kept as low as possible consistent with the obtaining of complete combustion.

Usually, the fireman is unable to exercise any control over the amount of secondary air admitted at the front wall of the furnace. He is forced to regulate the amount of secondary air admitted by varying the amount and rate of the discharge of coke into the clinker pit or over the end of the stoker. The operator should adjust the dampers, and when possible the rate of coal feed, of the different sections of the stoker so as to keep the surface of the ashpit well covered with coke without allowing the coke to become too deep in any special part.

Incandescent Surface of Clinker Pit

The operator, in controlling the rate of discharge of coke to the different sections of the pit, must be guided wholly by the appearance of the pit at these points. The flame from a fuel bed in which the volatile matter is not yet completely consumed, is white and luminous. When dry air is supplied, the only combustible gas that is given off from the fuel bed of coked coal is carbon monoxide, which burns with an almost invisible blue flame. When the proper conditions are being maintained, the surface of the clinker pit will be almost wholly incandescent, but there will be very little white flame arising from the pit. This is especially noticeable in the part farthest from the stoker-discharge portion.

There will be short streaks of black scattered over the surface of the pit which result from the coke being burned out at these points and the ash being cooled below the temperature of incandescence by the air passing through it. The presence of these black streaks is an indication that the coke section on the top of that portion of the pit is of proper thickness for best results.

The operator should know what values of excess air and combustible in the refuse result from maintaining different conditions at the discharge end of the stoker, so that he can tell what condition will result in the most economical balance between the stack and ashpit losses. In order to enable the operator to obtain a knowledge of the ashpit and stack losses resulting from the different conditions maintained in the clinker pit, it is well when possible to determine what these losses are for the different shifts on each boiler and report them to the operator.

A report of the excess air obtained with an underfeed stoker will be of almost no value unless it is also known what the ashpit loss was at the time the value of excess air reported was obtained. It is usually very easy to obtain high CO_2 with an underfeed stoker if the combustible in the refuse is allowed to become high. However, it requires good operation to obtain high values of CO_2 and still keep the combustible in the refuse at a low value.

Maintain Constant Elevation of Ashpit Refuse

The clinker grinders on underfeed stokers should be operated so as to keep the refuse moving down continuously. This should be maintained at a nearly constant level in the ashpit. Variations of the level in the pit cause variations in the amount of coke discharged into the pit, which in turn tend to increase the combustible in the ash. Extreme changes in the pit level are likely to cause clinkering. If the contents of the pit are suddenly lowered after having been allowed to become too high, a large amount of coke discharges into the pit from the fuel bed, which frequently results in the temperature of the refuse being raised to a point where the ash fuses and clinkers form. The level of the pit should be maintained such that the surfaces of the end grates or the stoker noses are well covered at all times with fuel, as shown in the figure, but the level should not be permitted to come so high that the thickness of the fuel bed on the stoker is unduly increased.

If there is a tendency for the fuel bed on the grates to burn out in ridges over the tuyeres of the stoker, resulting in a corrugated condition, it can often be improved by carrying the pit level higher so as to cause the thickness of the whole fuel bed to be increased. The thickness of the fuel bed at the nose of the stoker can usually be reduced by decreasing the movement of the secondary rams and by lowering the level of the ashpit.

Clean Side Walls at Least Every Eight Hours

Sometimes the fuel at the point of discharge into the ashpit becomes very thick, resulting in shearing the bed as it passes over the nose of the stoker. This condition is undesirable as it not only increases the resistance of the fuel bed to the flow of air, but results in uneven distribution of the coke that is discharged into the clinker pit.

Clinkers that form on the side walls of the furnace should be removed at least once every eight hours, although these do not usually interfere with the operation of the stoker. When allowed to accumulate, however, they keep the end tuyeres from being covered with live fuel and result in the admission of a considerable amount of oxygen at a place where it cannot mix well with the combustible gases arising from the other portions of the fuel bed. A consequent increase in the amount of excess air is produced. In stokers equipped with dump grates particular care must be taken to see that they are well covered with live fuel or large excess-air losses will result.

These three items, namely, the stack temperature, the combustible in the refuse and the CO_2 percentage, should always be watched. The values of these almost wholly determine what efficiency is obtained in the generation of steam for any particular kind of fuel. However, care should be taken that so much attention be not given to any one of these items as to permit the others being forgotten.

For any given boiler the stack temperature is a function of the rating carried on the boiler. The amount by which the stack temperature is above the steam temperature usually varies directly with the boiler rating. The curve of efficiency to rating is usually such that it is most economical to divide equally the load among boilers when the boilers and furnaces are the same. There is no economical advantage in forcing the boiler that has been cleaned last.

The coal supply, which by its shortage was expected to be for many years a serious handicap to German industry, is now more than ample on account of the very large development of lignite deposits.

Choice of the Prime Mover for an Ice Plant

By M. S. HOWARD

AT ONE time no one thought of using anything but a Corliss engine to drive an ice machine. An ice plant will require about 80 horsepower to freeze a ton of ice in 24 hours. For each ton 2,000 lb. of distilled water was required in the distilled-water ice plant, and with a loss of 10 per cent, 2,200 lb. was needed. An engine then that used 27 lb. of steam per brake horsepower would supply all the distilled water by its exhaust supply. If an engine used only 20 lb. per horsepower or 1,600 lb. for each ton of ice, an additional supply for makeup distilled water of 600 lb. of live steam would be used. There was then no incentive for an engine more economical than a simple Corliss. About the only place where even a compound engine was used was in plants where ice making was but part of the load, the main load being cold storage.

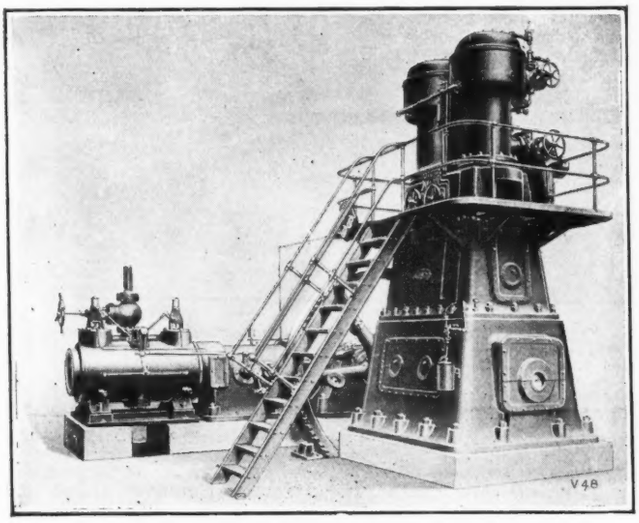


Fig. 1—Typical unaflow engine drive

Choice of Power Affected by Local Conditions

The perfection of raw-water ice systems enabled the plant owner to disregard the exhaust-steam proposition and install the most economical form of power possible. Broadly speaking, three sources of economical power are available, and the decision as to which is the most advisable depends upon local conditions, and it is impossible to state with any degree of definiteness that a steam engine, unaflow or Corliss compound, central-station service, or an oil engine should be decided upon unless all the facts are known.

These three power sources are those which should be given serious consideration, and in studying the power question there are several factors that should not be ignored.

The unaflow engine has a very low steam consumption, this being about 14 lb. per horsepower when operating condensing under a steam pressure of 150 lb. and with a 26 in. vacuum, and 18 lb. under non-condensing operation. If condensing water is not available, in all probability the steam engine will prove to be too expensive to operate. Considering the power requirements per ton of ice, about 80 hp.-hr. will be needed, which means 1,440 lb. of steam or about 200 lb. of coal per ton of refrigeration.

The steam plant will in almost all cases require both an engineer and a fireman per shift. Where labor is high, this extra labor must not be forgotten. The steam unit has, however, the advantage that it requires a small amount of repairs. In a plant under fair care the repairs per horsepower per year should not exceed one dollar, while the life of the plant should be at least 15 years. There is also the decided advantage of overload capacity. The steam unit should be able, if needed, to carry a 25 per cent overload for a long period. In the event one machine is down, a second unit can go far toward keeping the output up to normal. This is not true with either oil engines or electric motors.

High Fuel Costs for Steam Plant

Against the steam engine must be set the high fuel cost, for there is no indication that coal will be lower save during periods of industrial depression and with costs from $4 to $7, delivered, if a plant produces 7 tons of ice per ton of coal, the fuel cost alone will run from 50 to 90 cents a ton of ice. Labor in, say, a 50-ton plant, will average $30 a day or 60 cents a ton, while lubrication and engine supplies will call for about 2 cents more a ton, the other items of prime-mover operation being negligible. In other words, a unaflow engine will call for an operating cost of from $1.10 to $1.65 a ton of ice, and with an operating period of 200 days, the off-season labor will increase this by 15 to 20 cents. Considering only the steam end of the plant the investment will be around $3 per ton of plant capacity. Interest and other overhead at 15 per cent makes these

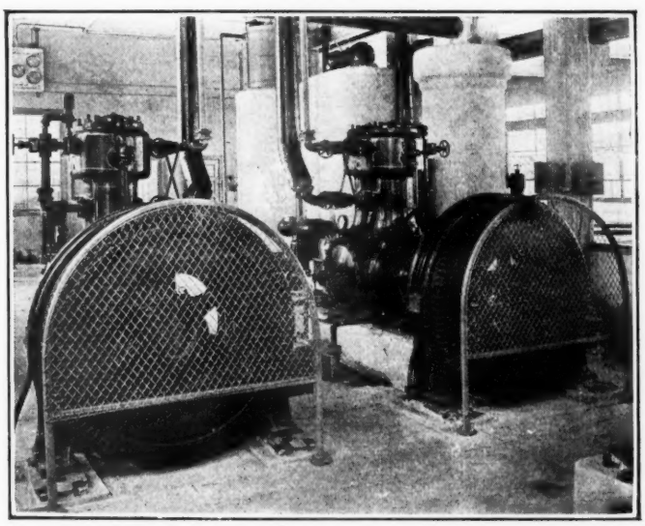


Fig. 2—Electric motors driving small compressors

figures up to 22 cents per ton, based on a 200-day operating year, or a total power cost of $1.87 per ton of ice manufactured, due to the prime movers alone.

Electric power is in many respects attractive to the plant owner since all difficulty of procuring fuel, etc., is lifted from his shoulders. Rates are low in many sections, contracts being made as low as 7 mills per kilowatt-hour in the larger Eastern cities. However, the rates more generally quoted range from 1½ to 3 cents per kilowatt-hour, including both service and demand charges. A rate of 1½ cents on the basis of 55 kilowatts per ton would make the power cost 82½ cents. Labor is reduced since only one man need be in the compressor room, and the labor per day will run around 35 cents a ton for a 50-ton plant and less, of course, as the plant capacity is increased. The power then costs around 72 cents a ton.

Extra Charge for Electric Current

Many electric companies charge, in addition to the base rate of so many mills or cents per kilowatt, an extra rate depending upon the maximum electric load occurring during a test month, say $1 per month per kilowatt of maximum demand. If the plant runs fully loaded in the summer months, a total of 120 kilowatts may be taken per hour. This calls for an additional monthly charge of $120 and as in most instances this is charged for all twelve months, it amounts to $1,440 a year to be added to the power bill. Not over 180 days of full-load operation occur, and during the winter season the load would not exceed one-half. Using a 50-ton plant as an example, the year's output would be 13,500 tons, which at 55 kilowatts a ton gives a meter reading of 742,500 kilowatt-hours, which at 1½ mills is $11,137. To this must be added 1,440 maximum demand, making the power bill per ton approximately 93 cents.

A rate of 2 to 3 cents a kilowatt-hour is not unusual in most of the Central West and Southern cities without a demand charge. This rate brings the power charge to well over a dollar a ton. It would appear that a rate of under 2 cents a kilowatt-hour makes electric power cheaper than the steam plant, with coal at usual prices.

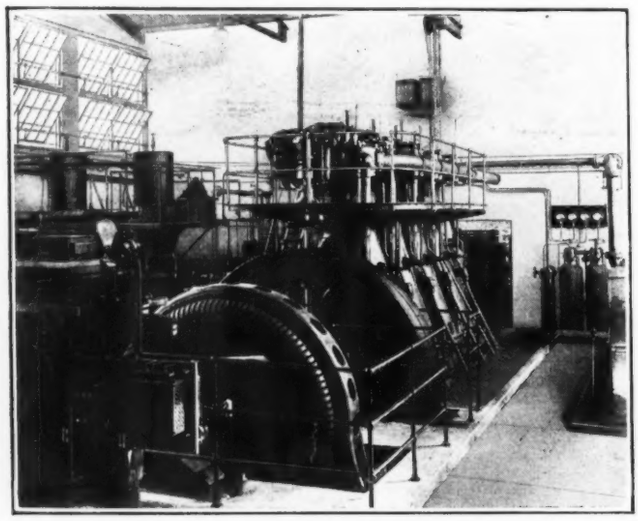


Fig. 3—Diesel engine carries ice plant load

The larger plants use synchronous motors almost exclusively and for this reason are justified in demanding the lowest rates in the central station's schedule. Small plants, by reason of the lower cost of the squirrel-cage motor, rather tend toward the use of this type. However, if there is a power-factor penalty in the electric contract, the synchronous motor should be used. While belt connection is often necessary in small plants owing to the excessive cost of slow-speed motors, direct connection is advisable whenever possible. In many instances the compressor flywheel may be dispensed with.

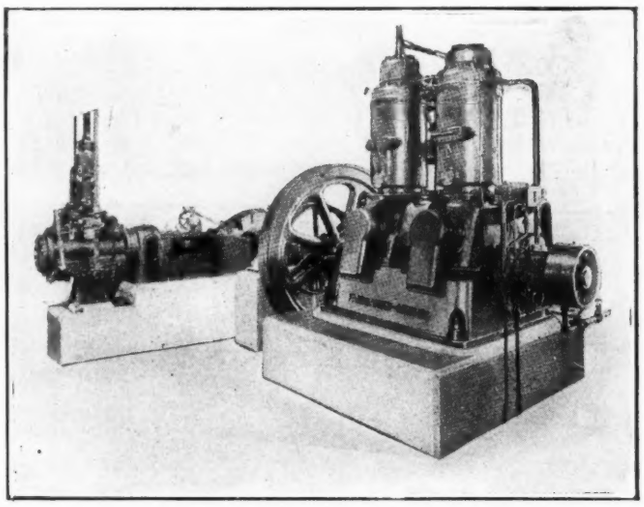


Fig. 4—Semi-Diesel direct connected to horizontal compressor

Turning now to the third form of power, there are two types of oil engine that should be considered, the Diesel and the surface-ignition or semi-Diesel engine.

Diesel-Engine Fuel Costs

The fuel consumption of the Diesel is about 0.45 lb. of fuel per horsepower or about 16 horsepower per gallon. For each ton of ice made the engine will require 4.8 gal. This oil may be purchased at around 4 cents a gallon, giving an oil cost of 19.2 cents a ton. But the labor will be about the same as with the motorized plant, say 35 cents a ton. In addition repairs will run to about $2 per horsepower per year, or with a 50-ton plant making 13,500 tons per year, around 2½ cents a ton. Lubricating oil will cost 2½ cents a ton and incidentals about 1 cent, making a total of 60 cents per ton of refrigeration. This is at first glance far below the cost of the other plants. However, the Diesel will cost $1 per horsepower of rated capacity or $330 per ton of plant capacity, or $16,000 for an engine to drive a 50-ton plant. Interest and overhead charges at 15 per cent total $2,400, and if 13,500 tons is put out, amount to 17½ cents a ton. The power is then costing about 77 cents per ton of refrigerating.

It would appear that the Diesel provides cheaper power than does the steam engine, and unless electric rates are low it is cheaper than purchased power.

The best makes of surface-ignition engines will deliver about 11 hp. per gallon of oil. This means about 7 gal. per ton of ice made, which at 4 cents means 28 cents for fuel. Labor will run about 30 cents, repairs about $2 per horsepower per year, or 2½ cents per ton. The lubricating-oil bill will be large, some engines using around a gallon for each 600 horsepower-hours An engine in a 50-ton plant will then use about 7 gal. per day costing 55 cents a gallon. This is 7.7 cents

a ton. The power costs will then average 78 cents a ton. Such engines will cost between $50 and $65 per horsepower or an engine for a 50-ton plant will cost not under $9,000. Overhead at 16 per cent and a tonnage of 13,500 tons give an overhead of 10 cents, bringing the power cost to 88 cents a ton.

For plants where the load is carried for only half the year, the semi-Diesel engine will often prove more economical than a Diesel, and the electric rate would need to be low to equal it.

Much, of course, depends on the electric rates obtainable and upon the cost of oil. The size of the plant influences the choice of power, for as the plant size increases the Diesel becomes more attractive, since the labor charge is reduced and the fuel makes up the bulk of the expense. In plants of over 50 tons it is questionable if the semi-Diesel can equal the Diesel's economy. It will be observed that the proper selection depends upon local conditions and cannot be determined without due investigation.

Steam at 1,200 Deg. F. in a Unique Power Plant

Steam pipes glow red at 750 deg. F. when viewed in the dark. The diminutive power plant shown herewith utilizes steam at full cherry red heat. Although this boiler and turbine are used for propelling torpedoes, there are features which suggest possibilities for more economical stationary practice.

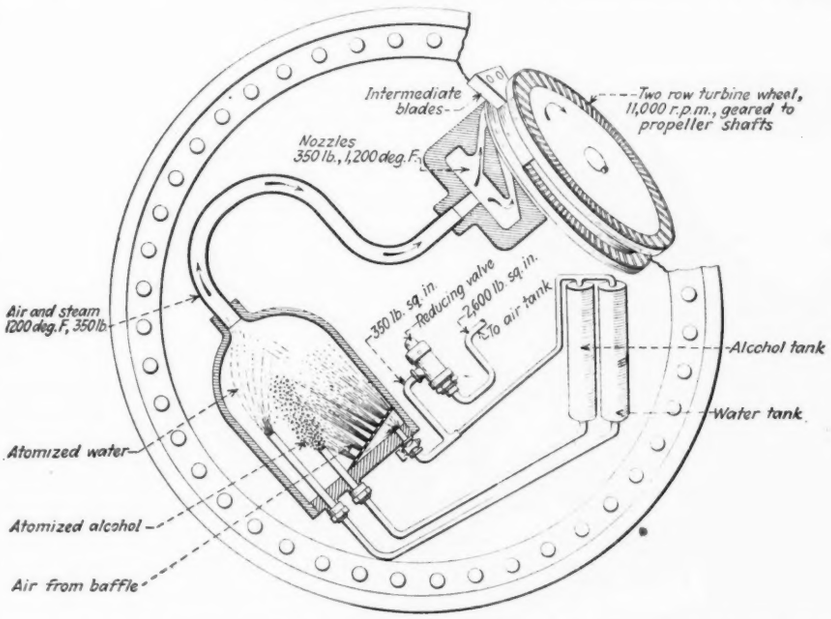
A TWENTY-YEAR advance over present steam-engineering practice is represented by the working temperature of 1,200 deg. F., with past progress as a measure. The difficulties of generating and utilizing the steam under such conditions can be realized from the fact that iron loses its strength to such a degree at red heat that the blacksmith can readily shape it with a hammer. Twelve hundred degrees, which is a cherry red, verges on this condition. A pressure of 350 lb. to the square inch is here applied, which makes these steam conditions all the more remarkable.

Although there are many ways of increasing plant economy, elevating the temperature of steam offers greater theoretical possibilities than any other means. It raises the possible limit to which engineers may strive as a goal. Four hundred degrees increase, as here would obtain, means that the Carnot or limiting efficiency is raised from about 55 to 66 per cent.

Raising the steam temperatures, however, is probably one of the most difficult means of improving plant efficiency. Ordinary metals become much weaker and what is more important, lose their elasticity at an even greater rate. New alloys must be developed to meet such conditions. It is not to be wondered at, therefore, that progress in this direction has been slow. The average rate of increase of steam temperature during the last ten years is about fifteen degrees per year, for land practice. In the future the rate of increase will probably be more rapid than in the past.

The torpedo power plant, unlike stationary plants, operates for short time intervals only. The average run is in the neighborhood of five minutes, and the total life of the turbine, without repairs, from fifty to two hundred hours. It is therefore far removed from conditions of stationary practice, where long uninterrupted operation is required. A turbine, however, for 1,200 deg. F., 350 lb., supplied by a boiler where fuel and water are intimately mixed, at high combustion efficiency, presents a new phase in regard to the possibilities of future progress.

Torpedoes were originally driven by compressed air. It was found that heating the air prevented freezing temperatures, incident to the expansion from heavy pressures to a low working pressure. Not only this, but the oxygen contained in a pound of air, if properly burned, would make it considerably more powerful and would also heat the air to 1,600 deg. F., which is much too high for ordinary materials.



Air, fuel and water are mixed in one chamber and supplied to turbine at 1,200 deg. F.

Inclined positions of boiler and turbine are unlike land practice. Although parts at high temperature are submerged in salt water, radiation loss is very low on account of high gas velocities.

In order to conserve the power represented by the difference in temperature of 1,200 deg., which is usable, and 1,600, which cannot be used, water is sprayed into

the mixture after combustion has taken place. This is in sufficient quantity to bring the temperature down to 1,100 or 1,200 deg. Steam of 350-lb. pressure therefore will be superheated about 700 deg. The air will thus have its working power increased about 250 per cent.

The simplicity and effectiveness of the plan in general can be seen in the figure. Air is stored at approximately 2,600 to 2,800 lb. per sq.in. and is fed through a reducing valve to the boiler, which it enters at approximately 350 lb. The air is admitted through holes in the baffle plate, so that it is diffused in the boiler.

Alcohol is atomized and injected into this air, allowing efficient combustion to take place. After this, atomized water is sprayed into the gases, so as to control the temperature. The boiler is comparatively small, being approximately 8 in. long, with the air, alcohol and water all injected at the bottom. The heated gases escape at the top, as indicated by the arrows. Valves are arranged so that, when igniting, the alcohol reaches the boiler before the water.

The construction of a torpedo is such that the boiler and piping are normally submerged in salt water. Efficiency is not a special object of this device, the boiler not even being lined with refractory material. There is, of course, good reason for this, inasmuch as the cooling action of the water tends to make the material of the piping better able to resist this temperature.

In spite of the fact that a difference of 1,000 deg. may exist between the heated gases and the surrounding water, the efficiency of combustion is not bad when compared with stationary practice, being upward of 96 per cent. As a complete boiler plant, however, the losses in compressing air would have to be considered. In this light, over-all efficiency is not so impressive. The slight loss from radiation can be explained from the fact that the gases travel at a high velocity, so that the short time element of transit allows but a small amount of heat to be lost in proportion to the total transmitted.

In order to obtain the atomized alcohol, it is necessary to supply a pressure to the alcohol tank slightly greater than that inside the boiler. A pipe is run from the low-pressure side of a reducing valve to the upper side of the tank. There is, also, a regulating valve placed between the air-reducing valve and the boiler, as shown in the figure. This valve may be adjusted to produce a small friction, thereby giving slightly greater pressure in the alcohol tank than inside of the boiler.

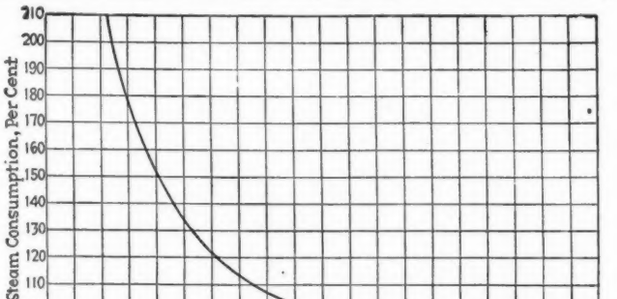
Water is supplied and atomized in the same manner. It is much better to use pure water for this purpose than sea water, as the latter contains salts and other impurities and may not only fill up the buckets of the turbine with sediment, but also would corrode the mechanism.

There is a two-row velocity stage turbine wheel of approximately 11-in. diameter, rotating at 11,000 r.p.m., geared to the propeller shafts. A torpedo contains two propellers rotating in opposite directions, one shaft being contained inside of the other. The blade speed is approximately 525 ft. per sec., with buckets made of drop-forged nickel steel containing shroud rings riveted on their ends. The turbine can produce between 100 and 200 hp. It weighs in the neighborhood of 20 lb. representing from one-tenth to two-tenths of a pound per horsepower. This is about one per cent of the weight per horsepower in large central-station machines.

Effect of Excessive or Insufficient Radiator Surface on Steam Consumption

Although it has been apparent for some years that insufficient radiation causes excessive steam consumption, the exact causes of the heat loss have been somewhat uncertain. In order to investigate this, a building so fitted that the amount of radiating surface could be varied at will, was maintained at a temperature of 70 deg. F. between 8 a.m. and 5:30 p.m. Readings were taken every half-hour with different amounts of heating surface.

It was brought out that if the unutilized losses from the piping are not considered, then there is little difference in steam consumption per hour, irrespective of the amount of radiation surface for the same outside



Insufficient radiating surface increases heating steam consumption

condition. The length of time necessary, however, to bring the building up to temperature was considerably greater with the small amounts of radiation than with the required amount. Thus 20 per cent of the required radiation took more than six times as long to heat up as with a normal amount, and 60 per cent radiation required approximately twice the normal time. The variation in the length of time therefore, affected the losses considerably.

The effect on steam consumption is most marked at low outside temperature, there being little difference between many of the tests with an outside temperature of 60 deg. This follows from the fact that the heating-up period is shorter in warm weather and the cooling-off period longer, so steam can be turned off at 2 p.m. in 60-deg. weather, and at 4 p.m. when 40 degrees.

The figure shows the percentage of steam consumption with over- and under-radiation and how the latter causes high steam costs. Over-radiation, on the other hand, involves an excessive installation cost. Computations were made according to the method prescribed by the National District Heating Association, under whose auspices the test was conducted, the results appearing in a paper entitled "Report of the Heat Utilization Committee," at the recent New York Spring convention.

Savings possible by proper radiation are due to having steam turned off for maximum periods at night. This applies not only to actual installed radiation but to the effectiveness of radiation. The customary method of bronzing or aluminizing radiators reduces their effectiveness as much as 25 per cent.

Some Facts Coal Buyers Will Find Worth Knowing

By C. C. Hermann

Purchasing agents or those having direct charge of the buying of coal for the power house too often are inclined to think that a pound of coal is a pound of coal, no more and no less. Some have broadened their visions to the point where they can see the advantage of placing contracts on a heating-value basis. Unfortunately, these display a tendency to make the B.t.u. value the sole factor in checking the comparative values of two different coals, when, in fact, there are other factors of equal importance.

In studying coal values, selection may be made on the basis of either of two considerations, these being *economic choice* and *operating choice*.

Economic choice with regard to coal is based on the relative price of the coal delivered, its relative heat value and the relative ash, or non-combustible matter, in the coal.

The operating choice of a coal is based on four considerations: The firing equipment, the boiler setting, the plant location with respect to smoke ordinances, and the operating rating of the boilers.

When comparing coal prices, they should be on a delivered basis owing to the variance in freight rates from different districts. A coal from a district taking a higher freight rate may be more economical than the one in use. However, unless the coal is compared on a delivered price basis, there is a danger of having the ultimate cost per million B.t.u. run higher than the actual difference in the coal would warrant.

Before one can compare prices intelligently, it is necessary to determine what kinds of coal can be used. Some buyers blindly buy a certain kind simply because they do not know that another kind or grade may be used in the plant. Seldom is a plant absolutely tied down to a certain grade of coal by reason of equipment or operating conditions. There may be a coal that works best under the conditions, but that very grade may be produced by a hundred different mines; this is the information that is of importance to the purchasing agent. More often two, and many times even three, qualities of coal will be found to give satisfactory results in the plant.

Screenings have been used in a hand-fired boiler satisfactorily and then a change made to a six-by-three egg without any dire results. Screenings of various sizes may be purchased, from washed to two-inch, all of which should be taken into consideration before placing a contract.

Another point worth attention is the quality of coal to be specified. Bituminous coal may be preferable; however, semi-bituminous and anthracite coal may be substituted, possibly at a decreased ultimate cost.

The coal must be compared on an ash and other non-combustible matter basis as well as on a price basis if the most economical coal is to be obtained. Moisture is of much importance, for it not only displaces a portion of coal by its weight, but also reduces the effective heat during combustion. Water takes one B.t.u. per pound per degree rise in temperature F., 970 B.t.u. per pound to evaporate it from and at 212 deg. F. and 0.5 B.t.u. per degree temperature increase per pound of steam to superheat it to the stack temperature. If it were possible to condense the steam to water again within the confines of the boiler setting, then this heat would not be wasted. However, this is not possible and this heat absorption represents an actual loss.

Ash is the residue that remains after the fuel has been completely burned. All coal contains non-combustible inorganic matter such as sand, shale, etc., in varying quantities upon which freight must be paid and which must be removed from the premises after the coal has been burned.

Information as to the operating choice must, of course, be compiled by the chief fireman or the engineer-in-charge; if it is to be of value, it must be compiled without fear or favor and based upon actual conditions. It is a well-known fact that the best of coal may be burned in very unsatisfactory manner if the fireman wants to be contrary. For instance, coal may be forced through the grate bars by the excessive use of the slice bar. A boiler operated by opening and closing the ashpit doors instead of being equipped with a stack damper, will throw away enough heat to offset the saving over a higher grade of coal.

If the plant is equipped with coal-crushing equipment, almost any size of coal may be used. The same holds true with the ordinary hand-fired plant as well as with the plant equipped with the underfeed stoker. For any other type of stoker-fired plant the size must be limited to the small nut sizes and screenings. Since almost any coal may be obtained in these sizes, a wide field of choice is still available to the purchasing department.

Kind of Coal That Can Be Used Affected by Boiler Setting

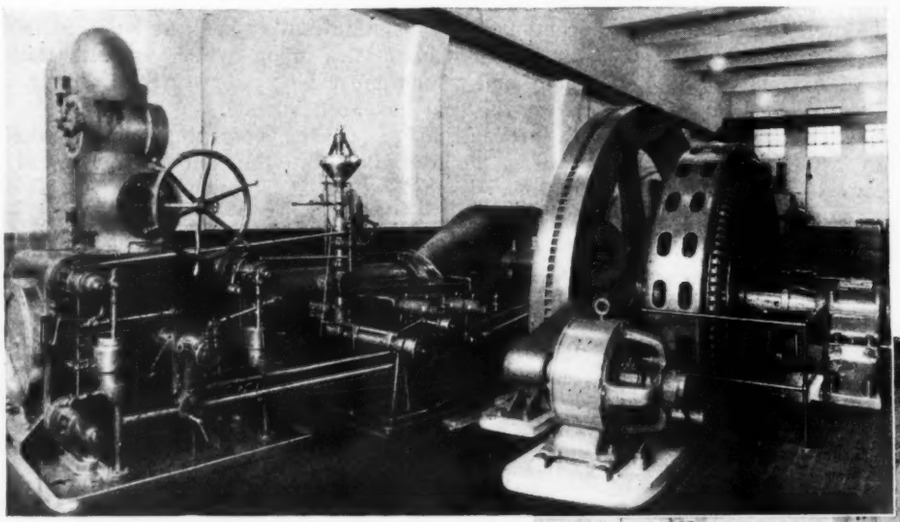
The boiler setting influences the kind of coal that may be used. A high setting provides a large combustion chamber and permits the use of either high- or low-volatile coals, but with a low setting only the low-volatile coals may be burned satisfactorily with regard to smoke. High-volatile coals burned in the low setting throw considerable combustible gas into the stack, causing a rise in stack temperature and reduced economy.

Every power-plant operator endeavors to operate his plant as nearly smokeless as possible. Many are forced to do so, owing to plant location and city ordinances. If the plant is in a residence section of the community, the smoke must be kept at a minimum and a coal must be selected that will throw off a minimum of smoke. The setting will have much to do with the smoke control, as has been outlined.

Where the boilers are operated at a high rating, one of the most important considerations is the fusion temperature of the ash. Even here much will depend on the fireman as to the amount of trouble encountered. If a free use of the slice bar is tolerated, whereby the ash is turned up into the high temperature of the flame, the ash will melt, run together and result in clinkering. The furnace temperature of a high-rating boiler is intense and therefore a coal having a high ash-fusion point should be given the preference. Many purchasing agents do not understand just what is meant by ash fusion. It is the temperature at which the ash melts; ash in one coal may melt at, say, 2,100 deg., and in another at 2,600. Fusion temperatures as low as 1,800 deg. F. are not uncommon in the Western bituminous coals.

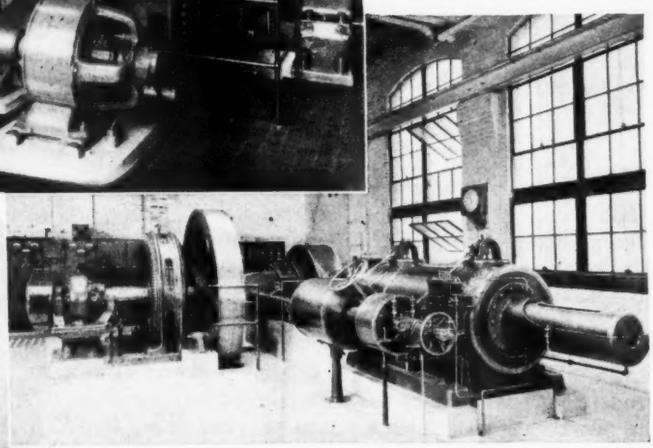
Taken all in all, every power-plant coal buyer, regardless of location, will find that there is a wide field of suitable coals from which to choose.

Grand Rapids Plants of Interest

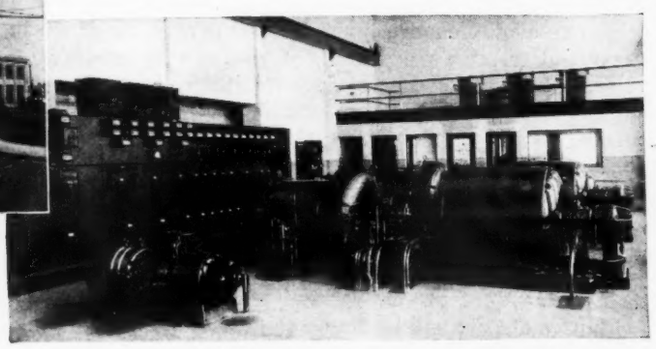


Left, engine room of Imperial Furniture Co., 640 Broadway Ave., W. H. Yoemans, Ch. Eng.

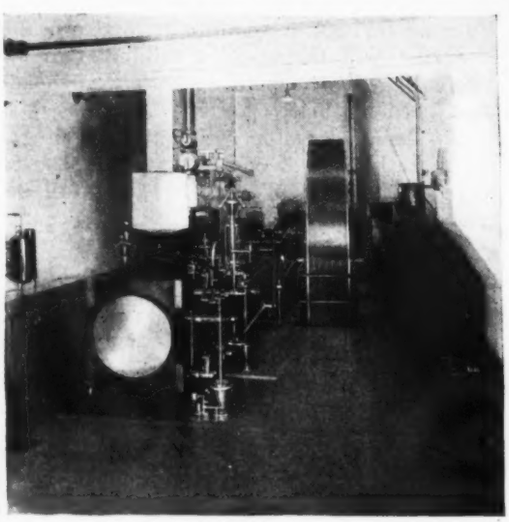
Below — Unaflow engine at plant of John Widdicomb Co., 601 Fifth St., Geo. O. Rogers, Ch. Eng.



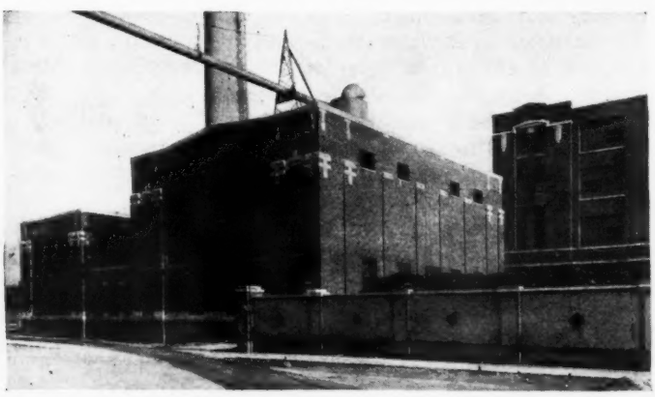
City Water & Lighting Plant, Monroe Ave. & Colbrook St.



Bleeder turbines at plant of Berkey & Gay Furniture Co., Ottawa Ave. & Walbridge St., W. L. Townsend, Ch. Eng.



Corliss engine and rope drive at Grand Rapids Chair Co., 1661 Monroe Ave., John Horton, Ch. Eng.



New Plant of American Seating Co., 901 Broadway Ave., W. M. Gormley, Ch. Eng.

This is a preliminary digest of the stationary engineers' license laws in the several states and cities of the United States. Owing to lack of affording a permanent reference for operating engineers. To this end readers will render a permanent service, not only

States and Cities	Laws—State and Municipal	Examination Required	Grades and Requirements of Licenses	Citizenship and Age Limit	Fee	Apply to	Remarks
Alabama	No state law	No					No provision in Civil Code
Birmingham	No record						
Arizona	No state law	No					
Phoenix	No record						
Arkansas	No state law	No					
Little Rock	No record						
California	No state law Municipal regulation						
Los Angeles	Ord. No. 33, 512. Ord. No. 38,872-73, 41,463 new series	Yes. Fifty points for experience, 25 for written and 25 for demonstration. Passing mark is 65	Grade, Steam Engineer: Affidavit as to previous employment must be furnished. 1 year's experience	21 years	$5	Board of Mechanical Engineers, Room 208; North Annex, City Hall.	Money not returned in case of failure of applicant to pass examination, but another examination may be taken within 30 days without additional payment. Examination held each Wednesday.
Oakland	No record						
Sacramento	No laws*	No					
San Francisco	Ord. 118 new series (1906) Inactive	No					No license required*.
Colorado	No record	No					
Denver	Chapter "I." Municipal Code of City and County, 1906, amended by Ord. No. 46, 1914.	Yes, for boilers of 15 lb. pressure and over	Engineer's license: Two years' experience. Must be vouched for by two citizens of Denver.	21 years	$10	Board of Examining Engineers Department, 204 City Hall.	New Ordinance in course of preparation.
			Boiler or water tender: Must have knowledge of operation etc., of steam boiler.	21 years	$1		
Pueblo	Ord. No. 984	Yes, for boilers of more than 15 lb. pressure.	Engineer's license: Two year's experience.	Must be U. S. citizen.	$2	City Council, care of Boiler Inspector	Boiler tender's license applies only to person tending detached boiler.
			Boiler or water tender license. Must have knowledge of operation, etc.	Must be U. S. citizen.	$1		
Connecticut	No state law*	No					
Bridgeport	No law*	No					
Hartford	No law	No					
New Haven	Amendments to Sec. 296-305, City Ord.	Yes	License only good for operating boiler for which application is made.		$5	Board of Examiners of Engineers, Room 3, City Hall.	
Delaware	No record						Has laws covering portable boiler operation.
Wilmington	Municipal law	Yes	1st class		$5	Board of Examiners, Stationary Engineers.	Also class for hoisting machinery.
			2nd class		$5		
			3rd class		$5		
			Hoisting engineer		$5		
			Fireman's license		$1		
Dist. of Columbia	Public No. 92	Yes	1st class; unlimited; 2nd class, one to 75 hp.; 3rd class, one to 25 hp.; applicant must be vouched for by three citizens of the District of Columbia.	21 years	$3	For blank application, apply to Assessor's office, District Bldg.	Board meetings for examinations of engineers held on Friday at 6 p.m. Fee refunded in case applicant fails to pass.
Florida	Sec. 1943-45						Authorizes cities of 5,000 inhabitants power to appoint examiner or inspector to grant licenses and to provide ordinance.
Jacksonville	No laws*						
Tallahassee	No law*						
Georgia	Sec. 528 (a). (627 a) Civil Code.					Board of Examiners in* respective counties.	
Atlanta	No record						
Augusta	No record						
Idaho	No law*						
Boise	No law*						
Illinois	Par. 439 of Cities and Villages Act, Chap. 24 Hurd's Statutes 1919						Power to license delegated to* cities and villages under law.
Aurora	No laws*	No					Ordinance being considered.
Chicago	City Ord. Sec. 3628-3640	Yes for boilers over 10 lb. pressure	Engineer's license: Two years' experience—vouched for by two citizens of Chicago.	21 years	$2	Board of Examining Engineers, Room 1008, City Hall.	Daily sessions of Board held.
			Boiler tender's license: Must have knowledge of boilers and be vouched for by two citizens of Chicago.	21 years	$1		
Decatur	Ord.*	Yes for boiler over 15 lb. pressure	1st grade: Unlimited; Two years' practice and vouched for by two or more citizens.	21 years	$5	Board of Examiners Steam Engineers, City Clerk's office.	
			2nd grade: Not exceeding 75 hp., can also act as asst. in large plants; six months' experience; vouched for by two or more citizens.	21 years	$5		
Elgin	City Ord.	Yes for over 15 lb.	Application for individual plant: Engineer's license, one year's practical experience.	20 years	$1	Board of Examining Engineers, Room 11, City Hall.	Board holds meetings on first Monday of each month. Younger man may be licensed by unanimous consent of Board. Permission for changing from one plant to another must be obtained.
			Boiler tender, 1 year's practical experience.	20 years	$1		
East St. Louis	No record						
Evanston	No record						
Peoria	City Ord. Chap. 56	Yes for boilers over 15 lbs.	1st class: Unlimited; three years' experience required.		$5	Board of Examiners care of Boiler Inspector's office—or City Clerk.	
			2nd class: Up to and not exceeding 250 hp., three years' experience.		$5		
			Boiler tender's license for individual plant only.		$3		
Rockford	No city ordinances*	No					
Springfield							
Indiana	No law*						
Goshen	No record						
Indianapolis	No record						
South Bend	No record						
Terre Haute	Gen. Ord. No. 159	Yes for more than 15 lb. pressure	At least two years' practical experience in firing and one year's experience in operating for all applicants, 1st class, five years' experience and a grade of 90 or more; 2nd class, five years' experience and a grade of 75 or less than 90; 3rd class, operates under direct supervision of 1st or 2nd class licensed engineer.	U. S. Citizen 21 years	$3	Board of Examining Engineers, City Hall.	Meetings every Monday evening at 7:30 p.m.
Iowa	Municipal regulation						
Des Moines	Ord. No. 2739 (1919)	Yes	1st class: Unlimited, five years' experience.		$4	Board of Examining Engineers, Department of Public Safety.	
			2nd class: 200 hp. and		$3		

States and Cities
Flint
Grand Rapids
†Jackson
Minnesota
Mississippi
Meridian
Missouri
Kansas City
St. Joseph
St. Louis
Montana
Nebraska
Omaha

Power's Digest of Stationary Engineers' License Laws

s. Owing to lack of uniformity in administration of the laws, the information had to be compiled from various sources, hence is
ent service, not only to *Power*, but to their fellow engineers as well, by sending in copies of the laws and application blanks for

States and Cities	Laws—State and Municipal	Examination Required	Grades and Requirements of Licenses	Citizenship and Age Limit	Fee	Apply to	Remarks
Flint	No law*						
Grand Rapids	No law*						
†Jackson	No law*						
Minnesota	State law, Chap. 31, Sec. 4750-55; Chap. 83, G. L. 1921	Yes	Chief engineer: unlimited, five years' experience required.	21 years citizen of U. S. or declared intention to become one	$7	Apply to District Boiler Inspector District 1—Alex Ferguson, Whalen; District 2—John Frisch, Minneiska; District 3—W. C. Allen, Plainview; District 4—George Ebel, Rochester; District 5—G. Hauenstein, Austin; District 6—I. A. Bottolson, Albert Lee; District 7—Fred J. Spencer, Blue Earth; District 8—F. L. Warrent, Kasota; District 9 Gust Fabianke, Sherburn; District 10—Endrew Elness, Windom; District 11—Gust Fabianke; Sherburn; District 12—Andrew Everson, Pipestone; District 13—John Beever, Marshall; District 14—Fred Prahl, Comfrey; District 15—E. O. Knutson, Nicollet; District 16—J. P. Peterson, Ellendale; District 17—F. L. Warrent, Kasota; District 18—S. L. Manhart, Northfield; District 19—J. W. Wiech, Red Wing; District 20—H. A. Otte, Farmington; District 21—H. M. Sebek, Belle Plaine; District 22—George Bonnitwell, Hutchinson; District 23—E. E. Hagquist, Hector; District 24—Jalmer Vane, Dawson; District 25—A. W. Vergstrom, Willmar; District 26—Helmer Olson, Litchfield; District 27—H. H. Knoll, Montrose; District 28-36—C.A.Stiehm, Minneapolis, 320 McKnight Bldg.; District 37-42—E. Jacobs, St. Paul, 3304 Ryan Bldg.; —Dist. 43—J. J. Doran, Stillwater; Dist. 44—Fred Whitney, Oak Grove; District 45—Otto Terwey, St. Joseph; District 46—Jacob Brick, Paynesville; District 47—J. C. Johnson, Alexandria; District 48—Otto Paulson, Wheaton; District 49—Sven Tweeton, Pelican Rapids; District 50—E. M. Miller, Fergus Falls; District 51—Louis Getzel, Verndale; District 52—L. R. Gift, Grand Rapids; District 53—L. E. D. Hanson, Bowlus; District 54—Wm. A. Gamble, Cloquet; District 55—M. Kaliher, Princeton; District 56—F. H. Walters, Hinckley; District 57-61—J. H. Bishop, Duluth, 326 Manhattan Bldg.; District 62—R. E. Miller, Bermidjt; District 63—Ole Engstad, Nevis; District 64—Ole Larson, Ada; District 65—A. W. Brink, St. Hilaire; District 66—M. C. Sheffloe, Crookston; District 67—Ole Mebust, Viking.	
			1st class: 300 hp. and under, three years' experience required.	11 years	$5		
					$3		
			2nd class: 100 hp. and under one year's experience	No age limit. Citizen of U. S. or declared intention to become one	$2		
			Special: 30 hp. and under.				
Mississippi	No state law*						
Meridian	No record						
Missouri	No record						
Kansas City	Ord. No. 8048 (1911)	Yes. for Class A and B licenses.	Stationary engineer's license 1st class fireman's license for boilers only. Portable engineers license.	18 years	$5 ($2.50 on application and $2.50 when given license	Board of Engineers, Office of Boiler Inspector, City Hall.	Reported to be considering regulations for refrigerating machines, U. S. license recognized for some purposes.
St. Joseph	Gen. Ord. No. 664	Yes	Engineer's license for high pressures.		$10	Board of Engineers, Office of Boiler Inspectors, City Hall.	U. S. License recognized when vised by Board.
			Portable engineer's license.		$7.50		
			Heating 15 lbs. of steam or over.		$5		
St. Louis	City Code (Revised; (1914) Art. XCI, Sec. 2191-98.	Yes	Engineer's license requires two years' experience and an oath as to truthfulness of application. Applicant must be recommended by two licensed engineers.	Must be citizen of U.S.	$5	Board of Engineers, 407 City Hall.	Applicant must be examined on engines, boilers, pumps, elevators, engine-room and steam-plant equipment. Licensed engineers must give notice of change of employment. Unlicensed persons may operate boiler of not over 75 sq.ft. of heating surface and not over 25 lb. pressure. Licensed engineers must report semi-annually on boiler under their charge. Failure to observe law results in fine and loss of license.
Montana	State Law—Art. 2, Sec. 1	Yes	1st class: unlimited; three years' experience.		$7.50	Inspector of Boilers, Butte, Helena, and Billings.	
			2nd class: 100 hp. and under; two years' experience.		$5		
			3rd class: 20 hp., one year's experience as fireman.		$3		

es, hence is incomplete. It is the intention to keep adding to the table as additional data are secured, with a view to blanks for cities or states not included in the table or revisions made since these data were secured

States and Cities	Laws—State and Municipal	Examination Required	Grades and Requirements of Licenses	Citizenship and Age Limit	Fee	Apply to	Remarks
New York City—Continued		three licensed engineers employed in New York City before examination.					
Niagara Falls	City Ord. Chap. 10, Sec. 1	Yes	Chief Engineer: Unlimited; 1st class, 300 hp.; 2nd class—75 hp. Special engineer's license relates only to plant applied for. Fireman's license: 1st class, 300-hp. boiler; 2nd class, 75 hp. boiler.	Citizen or declared intentions of becoming one.	$3 $3 $3	Board of Examiners of Stationary Engineers, City Clerk, Gluck Bldg.	Fee returned in case applicant fails in examination.
Rochester	Penal Ord., Sec. 1-18. (1914-15)	Yes, oral or written; optional	Chief engineer: unlimited. 1st class: 300 hp., one year's experience. 2nd class: 150 hp. 3rd class: 75 hp. Night watchman Hoisting and portable: 1st class 2nd class	 	$3 $3 $2 $2 $1 $3 $2	City Clerk's Office	All applications must be accompanied by the certificate of two reputable persons: Temporary license granted for two months. Application must state plant for which application is made
Schenectady	No laws*	No					
Syracuse	No laws*	No					
Troy	No record						
Utica	No laws*	No					
Yonkers	Gen. Ord. No. 3 (1918).	Yes. Applies only to particular plant.	1st class: unlimited, five years' practical experience. 2nd class: 200 hp. and under or asst. to 1st. class engineer. Three years' practical experience. 3rd class: 40 hp. and under, portable and hoisting engines. Two years' experience. Firemen: Detached boiler only.	 	$2 $2 $2 $2	Board of Examining Engineers, 114 City Hall.	A horsepower equivalent to 12 sq.ft. of heating surface. Application must be accompanied by certificate signed by employer. Board meets every Friday at 8 P.M.
North Carolina	No state laws*						
Charlotte	No record						
Wilmington	No record						
Winston	No record						
North Dakota	No state laws*						
Fargo	No laws*						
Ohio	State law, Chap. 13, Sec. 1040-57.	Yes, written, 50 questions. Applicant not understanding English examined orally.	1st class: Grade of 85 per cent. Three years' practical experience. 2nd class: 75 to 84 per cent grade, two years' experience. 3rd class: 70-74 per cent grade, one years' practical experience. Boiler operator: 70 or more, one year's experience.	21 years	$5	Apply to district examiners of stationary engineers, at 1st District—615 Marion Bldg., Cleveland; 2nd District, 430 Valentine Bldg., Toledo; 3rd District—317 Hartman-Ohio Bldg., Columbus; 4th District—Toulke Bldg., Chillicothe, O.; 5th District—719 Home Saving & Loan Bldg., Youngstown; 6th District—Room 7, Times-Recorder Bldg., Zanesville; 7th District—Room 97, Duttenbrofer Bldg., Cincinnati; 8th District—Room 416 Homes Bldg., Lima; 9th District—Room 213, Ludlow Bldg., Dayton; 10th District—Dime Savings Bank Bldg., Canton.	Twelve sq.ft. of heating surface equivalent to one horsepower. Examinations held in each district every Monday, legal holidays excepted. Examination covers construction and operation of steam boilers, steam engines, steam pumps and hydraulics. 70 is passing grade. Steam boiler under 30 hp. not included in classifications Apply to Industrial Relations Department, Columbus, Ohio; for application blanks. Fee not returned in case applicant fails in examination.
Oklahoma	No record						
Oklahoma City	No record						
Tulsa	Ord. 2460	Yes	Three grades		$3	Eng. License Board.	Law of 1923.
Oregon	No record						
Portland	No laws*						
Pennsylvania	State law No. 50 (1899), No. 75 (1905), No. 152 (1913).	Yes	Engineers—2 years' experience and two certificates, one from licensed engineer and one from employer. Portable boiler or engine, two years' experience—2 certificates.		$3		Law No. 50 (1899) applies to cities of 1st and 2nd class. Laws 75 (1905), and 152 (1913) to second and third class cities.
Altoona	No laws*						
Erie	City Ord. No. 5124 (1921)	Yes	1st class: unlimited 2nd class: 100 hp. and under, boilers and engines, and any hp. under chief. 3rd class: 50 hp. and operate engines up to 100 hp. under chief engineer. 4th class: Portable steam boiler and engine 5th class: Water tender under licensed engineer. 6th class: Watchman under licensed engineer.	21 years	$3	Boiler Inspector, Erie.	Two years' experience necessary for all grades of engineer's licenses. Technical school degree equivalent to one year. Must notify boiler inspector when taking or vacating a position.
Philadelphia	City Ord. (1916)	Yes	No grades specified. Two years' experience as helper or assistant.		$3	Bureau of Boiler Inspector, 301 City Hall.	License called a certificate.
Pittsburgh	Ord. 341 (1915)	Yes	Permit for operator: Two years' experience required, and must be vouched for by one licensed engineer and one employer.	21 years		City Boiler Inspector, Room 227, City-County Bldg., Pittsburgh.	License called a permit.
Reading	No Ordinance.* State laws regulate.						
Scranton	Ord. File of Common Council No. 37 (1907)	Yes	Must be vouched for by licensed engineer, two employers and one person for character voucher. State laws regulates.			Boiler and elevator inspection Division, Room 8, City Hall.	One square foot grate surface equivalent to three horsepower.
Wilkes Barre	No record						
Rhode Island	No state laws*						Licenses of nearby states recognized.
Providence	No laws*						
South Carolina	No record						
Charleston	No record						
Columbia	No laws*	No					
South Dakota	No state laws*						
Sioux Falls	No record						
Tennessee	No state laws*						
Knoxville	No record						
Memphis	City Ord. 1910	Yes, written, for boiler on 15 lb.	1st grade: limited. Three years' experience. 2nd grade: 75 hp. and under or act as assistant to 1st grade engineer. Three years' experience	Citizen of U. S. 21 years	$2 $2	Board of Examiners to examine and license engineers, Dept. of Public Utilities.	Fifteen square feet of heating surface equivalent to one horsepower. Application must be signed by two citizens of U. S., one of whom must be an engineer of steam user.

	nances						
Springfield							
Indiana	No law*						
Goshen	No record						
Indianapolis	No record						
South Bend	No record						
Terre Haute	Gen. Ord. No. 159	Yes for more than 15 lb. pressure	At least two years' practical experience in firing and one year's experience in operating for all applicants, 1st class, five years' experience and a grade of 90 or more; 2nd class, five years' experience and a grade of 75 or less than 90; 3rd class, operates under direct supervision of 1st or 2nd class licensed engineer.	U. S. Citizen 21 years	$3	Board of Examining Engineers, City Hall.	Meetings every Monday evening at 7:30 p.m.
Iowa	Municipal regulation						
Des Moines	Ord. No. 2739 (1919)	Yes	1st class: Unlimited, five years' experience.		$4	Board of Examining Engineers, Department of Public Safety.	
			2nd class: 200 hp. and under, three years' experience.		$3		
			Third class: 100 hp. and under.		$2		
			Fireman's license: 50 hp., 1 years' experience.		$1		
Sioux City	Ord. No. E641 (1898) Ord. L815	Yes for over 15 lb. pressure	1st grade, unlimited.		$3	Examining Board of Engineers	12 sq.ft. heating surface equals one horsepower. Two residents must vouch for applicant.
			2nd grade: 125 hp. and under		$3		
			3rd grade: 25 hp. and under		$3		
Kansas	Statutes, Sec. No. 1221, gives authority to cities						
Kansas City	No record						
Topeka	No law*						
Kentucky	No law*						
Louisville	No law*						
Louisiana	Ord. No. 6647†						Law, by court decision pronounced null and void. State versus Robertson.
New Orleans	No record						
Maine	Chapter 262, Public laws of 1917	Yes	1st grade-unlimited; 2nd grade under 500 hp.; 3rd grade under 200 hp.; special for individual plant.		$2		Gives authority to municipalities of over 40,000 inhabitants power to license. Person operating plant for 1 yr. exempt from examination must pay fees, however.
Bangor	No laws*	No					
Lewiston	No record						
Portland	No record	Yes, written	1st grade, unlimited; 2nd grade, 500 hp. and under; 3rd grade, 200 hp. and under; Special—for individual plant.		$2	Examiner of steam engineers, City.	Location of plant the applicant desires to operate must be given.
Maryland	Laws of Maryland 1910	Yes	1st grade, unlimited; 2nd grade, 1 to 500 hp.; 3rd grade, 1-30 hp.; 4th grade, hoisting.	21 years	$3	Board of Examining Engineers, Union Trust Bldg., Baltimore, Maryland.	This board examines for the whole state. Rules do not apply to persons operating boilers in sparsely settled country places, where not more than 20 persons are engaged in work about such boilers.
Baltimore	Charter, 1900 (Rev. Ed.)	Yes					
Massachusetts	Gen. Laws, Chap. 46, Sec. 46-52. State laws cover all towns and cities.	Yes	Engineer's licenses: 1st class—unlimited. Three years' experience or 2nd class license for 1½ years. 2nd class—Boiler or boilers and engines no one of which shall exceed 150 hp.—2 years' experience or held 3rd class license for 1 yr. 3rd class—for boiler or boilers not exceeding in aggregate 50 hp. each, or to operate a second class plant under the engineer in charge. 1½ years' experience or must have held 1st class fireman's license for 1 year. 4th class—Portable boilers.		$1 fee for each class license	Department of Public Safety, Division of Inspection, State House, Boston, Mass. Apply to Inspector of division for the town where applicant is resident or is employed.	Licenses granted according to competency of applicant, upon examination.
			Fireman's license: Extra 1st class—Operate any boiler. 1st class—for 25 lb. gage or high pressure boilers under engineer. 2nd class—operate under engineer in charge.				
			Special licenses: Operate particular plant and no other.				
Michigan	No state law Municipal regulation						
Bay City	City Ord. Sec. 9	Yes	1st class, unlimited	21 years	$5	Apply to City Boiler Inspector	
			2nd class, 50 hp. and under	21 years	$4		
			3rd class, 20 hp. and under	21 years	$3		
			4th class, heating boiler	21 years	$2		
			3rd and 4th classes can act as assistants to higher grade and operate heating boilers.				
Detroit	Ord. No. 710-A, 1920	Yes, written and oral for 1st and 2nd grades, oral for all others.	1st class: unlimited. (*a*) 5 years' experience as oiler or assistant under 1st. class engineer; (*b*) oiler or assistant on locomotive; (*c*) three years' experience as machinist boilermaker or steamfitter; (*d*) has held second grade license for two years in city of Detroit.	Citizen of U. S. or has taken out 1st papers within 5 years.	$3	Department of Building and Safety Engineering, City Service Bldg.	Examinations on Tuesdays and Thursdays of each week. Any city or state license will be acknowledged for proof.
			2nd class: 100 hp. and under; three years' experience operating a steam engine and boiler.		$3		
			3rd class: 50 hp. and under; 2 years' experience.		$3		
			Boiler operator for 15 lb. pressure heating boiler.		$2		
			Fireman's: 1 year's experience in firing boiler and oral examination.		$2		

***Information obtained from state or municipal officials. †From state documents.**

Montana

Nebraska

Omaha

Lincoln

Nevada

Reno

New Hampshire

Manchester

New Jersey

New Mexico

Albuquerque

New York

Albany

Buffalo

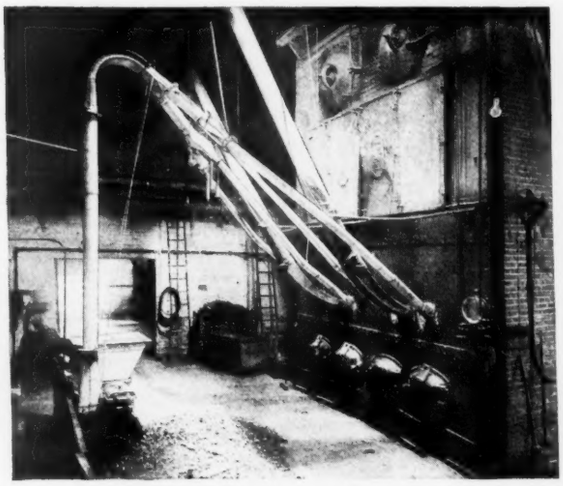
New York City.

	2191-96.		must be recommended by two licensed engineers.				equipment. Licensed engineers must give notice of change of employment. Unlicensed persons may operate boiler of not over 75 sq.ft. of heating surface and not over 25 lb. pressure. Licensed engineers must report semi-annually on boiler under their charge. Failure to observe law results in fine and loss of license.
Montana	State Law—Art. 2, Sec. 1	Yes	1st class: unlimited; three years' experience. 2nd class: 100 hp. and under; two years' experience. 3rd class: 20 hp., one year's experience as fireman.		$7.50 $5 $3	Inspector of Boilers, Butte, Helena, and Billings.	
Nebraska	No law* Municipal authority.						
Omaha	Ord. No. 11418 (1922).	Yes	1st grade: unlimited; two years' experience; vouched for by two citizens, one of whom must be a licensed engineer. 2nd grade: 100 hp. and under: two years' experience; vouched for by two citizens, one of whom is a licensed engineer. 3rd grade: 50 hp. and under. Heating certificate for plant 20 lb. pressure, 750 sq.ft. heating surface and under.	21 years	$5		
	Ord. 12158 (1921)		Hoisting and Portable Engineer: 1st grade covers steam, electric and gasoline power driven; 2d. grade covers electric and gasoline driven only.	21 years	$5		
Lincoln	No record						
Nevada	No record						
Reno	No record						
New Hampshire	No laws*						City Clerk of Manchester says the state has regulations.
Manchester	No laws*						
New Jersey	State law (1913). Chap. 363. Amended (1917). Chap. 251	Yes. Written, for boilers over 15 lb. pressure	License for Central Station or Industrial plant: Grade A: requires 80 per cent in examination, must hold B license and one year's experience as chief eng. in plant of 500 hp. or two year's practical experience as assistant in plant of 200 hp. or show equal experience in some other state; Grade B: 70 per cent in examination, hold a C license and one year's practical experience; Grade C: 60 per cent or more, two years' experience as boiler operator or one year's experience as boiler operator and one year's experience as oiler; graduate of technical school and one year's experience; machinist must have served apprenticeship and one year's operating experience. Refrigerating Plants: Grades A, B, C. Hoisting and locomotive cranes: Grades A, B, C. Boiler Operator: Three months' experience in boiler room.	Citizens or have taken out first papers. 18 years 18 years 18 years	$2 $2 $2	Department of Labor, Steam Engine and Boiler Operator's License Bureau, State Office Bldg., Trenton.	Examinations held on first Wednesday of each month at Trenton and at other central points as often as necessary. All applicants must be recommended by two licensed engineers. Non-resident must provide letter from employer.
New Mexico	No state law* Municipal regulation.						
Albuquerque	No law*						
New York	No state law Municipal regulation						
Albany	No laws*						
Buffalo	City Ord. Sec. 17-30	Yes, written	Chief Engineers: Unlimited. Three years' experience as first-class engineer, or elsewhere than in the city of Buffalo, three years' experience of steam plant over 75 hp. 1st class: 150 hp. and under. Two years' experience as 2nd class engineer or two years' experience in plant over 10 hp. 2nd class: 75 hp. and under. Three years' experience firing or as oiler and one year's experience in boiler room. Graduate from technical school and one year's experience. Special engineers for particular engine or boiler.	21 years Citizen, U. S.	$3		Engineer's license for school buildings is a separate license. U. S. licence not accepted without examination.
New York City	Charter, Chap. 466 (1901). Amendments to and including 1920 Chap. 8, Sec. 342-45.	Yes, written. Must file application which shows five years' record as to employment. Certificate signed by	Engineer—1st class, 2 years' experience and must be vouched for by a working licensed engineer of New York City. Fireman.	Citizen of U. S. over 21 years.	No fee	Police Department, Steam Boiler Inspection and Engineer's Bureau, 240 Center St., N. Y. C.	

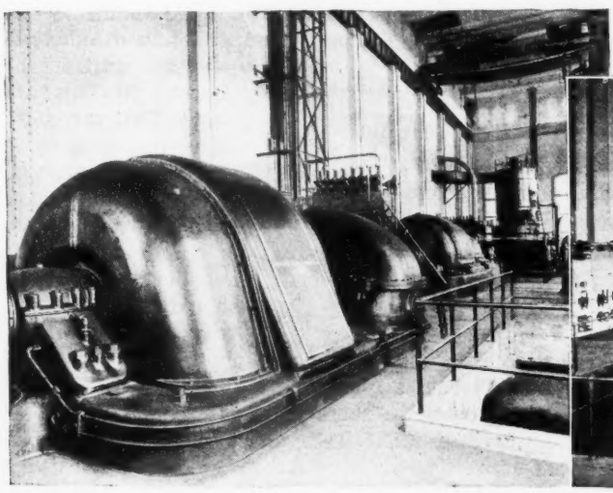
	Council No. 37 (1907)		employers and one person for character voucher. State laws regulates.				
Wilkes Barre	No record	.....	.....	.....	.....	.....	.....
Rhode Island	No state laws*	.....	.....	.....	.....	.....	Licenses of nearby states recognized.
Providence	No laws*	.....	.....	.....	.....	.....	.....
South Carolina	No record	.....	.....	.....	.....	.....	.....
Charleston	No record	.....	.....	.....	.....	.....	.....
Columbia	No laws*	No	.....	.....	.....	.....	.....
South Dakota	No state laws*	.....	.....	.....	.....	.....	.....
Sioux Falls	No record	.....	.....	.....	.....	.....	.....
Tennessee	No state laws*	.....	.....	.....	.....	.....	.....
Knoxville	No record	.....	.....	.....	.....	.....	.....
Memphis	City Ord. 1910	Yes, written, for boiler on 15 lb.	1st grade: limited. Three years' experience. 2nd grade: 75 hp. and under or act as assistant to 1st grade engineer. Three years' experience. 3rd grade: 25 hp. and under and act as assistant to 1st or 2nd grade engineer. Three years' experience.	Citizen of U. S. 21 years	$2 $2 $2	Board of Examiners to examine and license engineers, Dept. of Public Utilities.	Fifteen square feet of heating surface equivalent to one horsepower. Application must be signed by two citizens of U. S., one of whom must be an engineer of steam user.
Texas	No record	.....	.....	.....	.....	.....	.....
Austin	No record	.....	.....	.....	.....	.....	.....
Dallas	No record	.....	.....	.....	.....	.....	.....
Fort Worth	No record	.....	.....	.....	.....	.....	.....
Houston	City Ord. Art. 2, sec. 1900	Yes, written, for boilers over 10 lb.	1st class: Three years' experience and grade of 85 per cent or more. 2nd class: Two years' experience and making grade of 75 per cent or more. 3rd class: one year's experience and a grade of 70 per cent or more.	Lawful age.	$4	Secretary, Board of Examiners Stationary Engineer's License, Public Service Dept.	.....
San Antonio	No laws*	No	.....	.....	.....	.....	.....
Utah	No record	.....	.....	.....	.....	.....	.....
Ogden	No laws*	.....	.....	.....	.....	.....	.....
Salt Lake City	No laws*	.....	.....	.....	.....	.....	.....
Vermont	No record	.....	.....	.....	.....	.....	.....
Burlington	No record	.....	.....	.....	.....	.....	.....
Virginia	No law*	No	.....	.....	.....	.....	.....
Norfolk	No law*	No	.....	.....	.....	.....	.....
Richmond	No law*	No	.....	.....	.....	.....	.....
Washington	State law*	.....	.....	.....	.....	.....	.....
Olympia	No record	.....	.....	.....	.....	.....	.....
Seattle	Ord. 32034. Sec. 1-17 (1913).	Yes, written and oral	1st chief engineer: unlimited three years' experience. 2nd grade: 1,500 hp. Three years' experience. 3rd grade: 500 hp. Three years experience. 4th grade: Fireman operating boilers only. One year's experience. 5th grade: Fireman in charge of boilers limited to 15 lb. pressure.	21 years	$2 for all grades	Civil service Commission, City-County Bldg.	Trade certificate must be signed by engineer, fireman or employer. Must notify Boiler Inspector any change of address or employment. Graduate of technical school with one year's practical experience may apply for 2nd and 3rd licenses.
Spokane	Ord. No. C2406, C1891, Amended Aug. 12, (1918), (1919.)	Yes	1st class: unlimited. Two years' experience. Technical school graduate, steam engineering and one year's experience. 2nd class: 200 hp. One year's practical experience or graduate of technical school steam engineering, and one year's experience. 3rd class: 100 hp. one year's practical experience. May act as assistant to 1st or 2nd class engineer. Fireman's license.	21 years 21 years 21 years 18 years	$4 $3 $2 $1	Board of Engineer's Examiner's, Department of Public Works.	One square foot of grade surface equivalent to 3 hp.
Tacoma	Ord. No. 5402 (1913)	Yes, written, for over 10 lb. per sq. in.	Three years experience or regular apprentice in machinist trade in steam engine works, for three years, or graduate of school of technology and one year's experience.	.....	$3	Board of Examiners, Care City Boiler Inspector, City Hall.	Name of plant must be specified. Must be certified to by one employer and two licensed engineers.
West Virginia	No state law* Municipal, regulation.	.....	.....	.....	.....	.....	.....
Charleston	No record	.....	.....	.....	.....	.....	.....
Huntington	Ord. Act of 1897, amended 1910	Yes, for boilers over 25 lb.	1st class: unlimited, one year's experience. 2nd class: 250 hp. and under, one year's experience. 3rd class: 75 hp. and under, 1 year's experience.	.....	$3	Board of Examiners, Huntington, W. Va.	License called Certificate of Qualification.
Wheeling	No laws*	No	.....	.....	.....	.....	.....
Wisconsin	No record	.....	.....	.....	.....	.....	.....
Kenosha	City Ord.	Yes	1st class: unlimited, two years' experience. 2nd class: 150 hp., two years' experience. 3rd class: 50 hp.; two years' experience.	Must have taken out 1st papers. 21 years 21 years 21 years	$2 $2 $2	Apply to Board of Examining Engineers.	Must be vouched for by two citizens of U. S. 2nd and 3rd classes may act as assistant to 1st class engineer. 10 sq.ft. of heating surface equivalent to 1 hp.
Milwaukee	Gen. Ord. Chap. 28, Sec. 1152-1169 (1914)	.....	1st class: unlimited machinist must have at least two years' experience operating. 2nd class: 300 hp. and under. Two years' experience. 3rd class: 75 hp. and under. Two years' experience. 2nd and 3rd class may be assistant to 1st class.	21 years for all grades.	$3 $3 $3	Board of Examiners of Stationary Engineers, City Hall.	Twelve square feet of heating surface equivalent to 1 hp. Must be vouched for by two citizens of Milwaukee. Engineer must report defects in boilers to Boiler Inspector.
Racine	No record	.....	.....	.....	.....	.....	.....
Stevens Point	No record	.....	.....	.....	.....	.....	.....
Wyoming	No state law*	.....	.....	.....	.....	.....	.....
Cheyenne	No record	.....	.....	.....	.....	.....	.....

to N.A.S.E. Convention Delegates

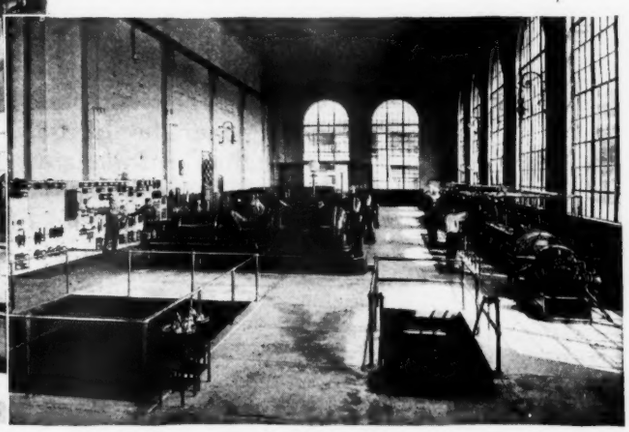
Klingman Building where mechanical exposition will be held



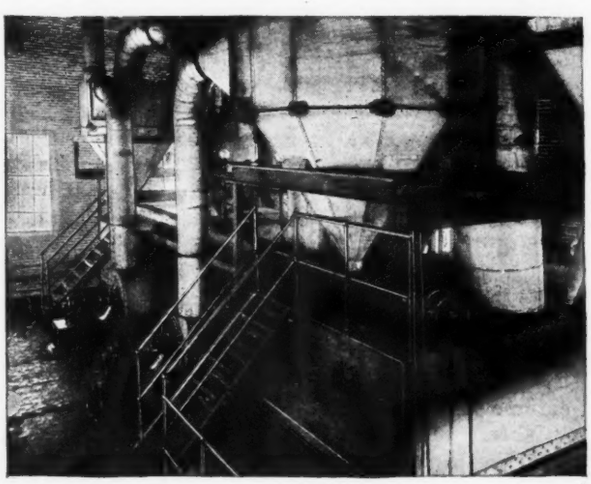
Feeding sawdust automatically at Imperial Furniture Co.'s plant



Turbine room of Wealthy St. station of Consumers Power Co., L. M. Hoyt, Ch. Eng.



Turbine room of City Lighting Plant, W. J. Grooters, Ch. Eng.



Pulverized coal storage at Grand Rapids Malleable Iron Works, A. B. Nordburg, Ch. Eng.

Hotel Pantlind—Convention headquarters

The Boiler-Water Problem

By WILLIAM MILLER BOOTH
Consulting Chemical Engineer, Syracuse, N. Y.

WELL-LOCATED power plants are provided with two or more independent sources of water supply. The general arrangement is the use of the best water available for the boiler, with a second supply often of inferior quality that may be used in case of emergency and that is satisfactory for many plant demands—for fire purposes, cooling, toilets and for some manufacturing operations. Whatever the source, boiler waters should not carry solids in suspension. Such waters should be filtered or run into tanks or ponds to remain at least twenty-four hours before using. Having once installed suitable settling or filtering equipment, little attention is required other than periodical cleaning.

While the separation of the solids in suspension is not difficult, the removal or reduction of matter in solution—that is, matter dissolved in water—is quite another affair, presenting a chemical problem often difficult to solve.

Water should in all instances be heated approximately to the boiling point before its introduction to the boiler. This has become almost universal practice in well-managed plants. The gases are in part, at least, automatically liberated, heat from returns is conserved and the bicarbonates of calcium and magnesium are partly broken down. Filtration and heat greatly improve a muddy water containing suspended mineral matter, decomposing organic matter, carbon dioxide, dissolved air, limestone and dolomite.

IN this article Mr. Booth outlines in non-technical language some of the principal things the engineer should consider in insuring a supply of suitable feed-water for his boilers. The advice given is based on extended experience as a consulting engineer in this field.

The temporary hardness of water can thus be reduced. The permanent or sulphate hardness remains. A closed pressure heater is required to effect the separation of this mineral. As "hardness"[1] is a term with which all are familiar, the waters of our Eastern and Middle Western manufacturing districts will be divided into three groups according to this classification. First, those with a hardness of less than 60 parts per million; second, from 60 to 150 parts per million; third, from 150 to 2,000 parts per million. Waters of each class are used daily in steam boilers.

Waters of the first class are usually handled without difficulty, particularly when little gypsum is present. An efficient heater will break down enough of the bicarbonate to produce a non-scaling, non-corrosive sediment that can be blown out. A very small percentage of alkali[2] can be added to the feed-water intake and pumped into the boiler. The addition should be made daily while the boiler is in service. A 1,500-sq.ft. boiler of either the fire-tube or water-tube type would normally need less than one pound of chemical per 24 hours. The type of alkali may be suggested by an experienced chemist. Engineers so fortunate as to operate with such a supply can usually keep their boiler tubes clean and free from scale or corrosion without additional equipment. However, a purifying plant may be used to good advantage.

Waters of the second class with a hardness of from 60 to 150 parts per million are very common in the districts covered by this article. Supplies from many of our rivers and lakes belong to this group. In all cases a good heater is necessary, and this should be kept clean. If no softening plant is used, boilers operating on waters of this class must be blown regularly, preferably from one-half to one gage during each eight-hour shift. Firemen are often forgetful of this duty, and some check should be devised in every plant to obtain uniform service in this particular.

The second method of handling semi-scaling waters is to use a standard boiler compound. We are not opposed to the use of these, but insist that they shall be uniform in quality and that an analysis shall accompany the contract of sale. A copy of this analysis should be given to the boiler inspector or sent to the company that he represents. No engineer should add a composition of unknown materials to a boiler, and no manager should allow an engineer to experiment with chemical compositions that he or his friends think will dissolve or remove scale.

The custom in some plants is to allow the boiler to take care of itself until about three weeks before the inspector is to arrive. A heavy dose of some powerful material is then added, followed by a general cleaning out. Such a procedure is unfair to the management that has suffered a pecuniary loss because of decreased steaming power of the apparatus. Further, the life of the boiler shell and tubes may be impaired by corrosion due either to the scale deposits or to the chemical added to the boiler.

The waters of the second or semi-scaling class are now being handled in an ever-increasing number by water-softening plants. Twenty years ago manufacturers of water-purifying apparatus found it extremely difficult to proportion chemicals to raw water. More recently, however, engineers and chemists have combined forces and have succeeded in developing excellent measuring devices. Power-plant operation is a thermal and a chemical problem from the time water enters the heaters and coal the firebox, until the steam has passed from the boiler and the flue gases have entered the stack.

Waters of the third class may be termed "hard." They scale boiler shells and tubes and in many instances are also corrosive if used in the untreated state. Power-plant managers who are compelled to generate steam from such waters find each case a specific problem and resort to the use of thermal or

[1] Oxides of calcium and magnesium reduced to the equivalent amount of calcium carbonate.

[2] Caustic soda, soda ash or tri-sodium phosphate or a mixture of these.

chemical treatment or both. Experienced engineers may handle very hard waters with compounds, simple settling tanks or heaters, provided the blowing-down process is carried out often and systematically. Steam may be generated from water containing 2,000 parts of dissolved solids per million, mainly of gypsum. In some instances this is accomplished by adding soda ash and caustic soda or both to a large settling tank outside the boiler house.

The purification of water as an engineering and chemical problem has reached such a stage that we recommend elimination of the scale-forming ingredients prior to its entrance to the boiler. The apparatus best adapted to the conditions must be chosen to meet the demands of the plant. To do this, successful installations may be examined and a type of apparatus chosen that seems to cover these.

If a water purifier of a well-known design is purchased, prepare to give it the same continued and careful treatment that you would give a boiler. Failures of standard plants are usually due to the lack of proper supervision and ignorance of the principles of water purification. It is not intended to overlook the promising field of water distillation for particular power-house managers whose demands are very exacting. A well-designed water-softening plant well run may be a splendid investment, while a poorly designed plant that makes it possible to overdose feed water with chemicals is about as dangerous a piece of apparatus for the boiler room as we can imagine in service. Lubricating oil is continually added to many boilers in the returns. No harmful result may be noticed for months. When a softener is installed and the water is made permanently alkaline, as it should be, an emulsion with oil is made that results in the carrying over of solid matter into the engine cylinder.

Scientific Proportioning Important

We have in mind two serious accidents from such a cause. Again, the lay mind cannot understand that caustic lime in excess should not be added to boiler-feed-water. We have found a water-tube boiler in very band condition with lime baked upon tubes and drum, due to such addition of caustic lime in the feed-water line. In a second instance an excess of lime passed into the cylinder and combined with the animal oil of the lubricant, forming lime-soap balls that scored the surface of the metal and necessitated reboring. We have often wondered how many cylinders have been injured by the entrainment of solid matter by steam.

While we have experienced serious difficulty from an excess of caustic lime in water purification, we have not had difficulty from a moderate excess of soda ash. Water that contained several hundred parts per million *excess* of this chemical gave entire satisfaction in service, and the boiler was clean within. Although probably well known the writer does not remember having read the statement that by increasing the phenolphthalein alkalinity of treated water to about fifty parts per million *above* that required by the softening formula, the lime and magnesium salts are practically eliminated. Ordinarily, about thirty parts per million residual calcium and magnesium, reckoned as carbonates, are found at the completion of the softening process.

With very hard water the complete softening of which would produce considerable sulphate of soda, it has been our custom to remove the lime and magnesium salts partly by frequent blowing down. The hardness of such supplies may be reduced to about 100 parts per million and run with an excess alkalinity of from fifty to sixty parts per million. Softened water that has been circulated before the precipitation of the lime and magnesium salts has been the cause of many failures. Any plant having more than 5,000 sq.ft. of boiler-heating surface should include in its regular employ an engineer or chemist with broad experience in the purification of water for boiler purposes.

Boiler Scale an Avoidable Evil

It is no longer necessary in any plant to operate with scaled boilers and reduced efficiency. Carefully operated boilers are clean, with black tubes, the water being so free from scale that it becomes unnecessary to open the boiler for a period of several months at a time. Instead of retubing boilers once in from two to four years where extremely bad water is used, it is now possible, with proper apparatus and efficient operating conditions, to use the same tubes from 15 to 20 years.

Expert control of the water of a boiler plant begins with the selection of the best supply, the installation of proper apparatus and daily chemical attention to steam production. After the consulting or managing engineers have done all that is possible in connection with the layout of a plant, the responsibility of daily and proper treatment of the water may be placed in the hands of a reliable young man who may have other duties about the boiler house or engine room.

In a few instances only do we believe this detailed work to be among the duties of the supervising engineer. If properly supervised by a water specialist, and rendering reliable and conscientious reports, a young man with a high-school education can be made responsible for the operation of even a highly organized water purification system. His duties include the collection of a daily sample of at least eight ounces from each boiler and a quart sample from the purifier on the raw-water and softened-water sides.

Pointers on Water Testing

An outfit consisting of burettes, measuring tubes, flasks, bunsen burner, an alcoholic solution of phenolphthalein, a distilled-water solution of methyl orange, a small water still and a few bottles for chemicals should be provided in the cleanest available part of the plant. The purified water should be tested daily for lime and magnesium. Honesty on the part of the boiler-room attendants is necessary. The process of drawing the water from the boilers is very much simplified by using a clean pail and filling the bottles for the day from this.

The boiler-water sample is, after all, the important index of correct water conditions. It differs in different boilers, as two units of the same type side by side will rarely produce an equal amount of steam; consequently, water is evaporated at a different rate with the production of more or less sediment.

Whatever the form of treatment, solids in solution will accumulate. It has been our experience that these mineral salts are built up until they represent from ten to fifty times the total solids of the raw water. We have recently tested samples from the boiler of a highly organized plant. This water contained 4,000 parts of dissolved solids per million, while the raw water had a total solid content of a little more than 200 parts per million.

Daily records of the hardness of the raw, purified and

boiler waters, the latter from each unit, with the percentage of hardness removed from purified and boiler samples, should be kept in a card-index file and should be studied by the engineer in charge. If the raw water contains calcium or magnesium chlorides, *it is imperative* that these should be transformed into non-corrosive salts.

When turbines are in use, the makeup raw water must be of excellent quality or severe corrosion may result. The production of iron rust and red water in a boiler, the raw supply of which contains little if any oxide of iron, indicates a serious condition, and immediate action toward its correction should be undertaken. The general supposition that steam is free from impurities needs to be corrected. The half-bound carbon dioxide of carbonates, occluded air, rich in oxygen, and ammonia are among the volatile materials carried over.

The ideal boiler water neither scales nor corrodes It is seldom found in practice. Its production is now being undertaken by many engineers and chemists.

Setting Steam Valves of Duplex Pump

When a direct-acting duplex steam pump suddenly takes to running lame or pounding, the operator's first impression is that the steam valve gear is at fault. The pump may short stroke from too much friction of pistons or piston-rod packing or may pound from loss of cushion or from running the pump faster than usual

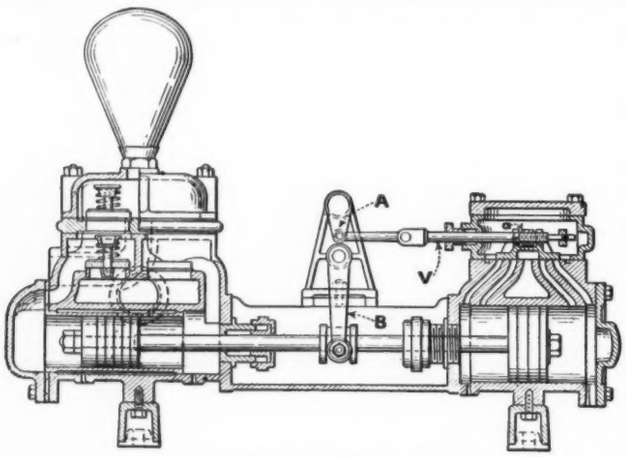


Fig. 1—Duplex Steam Pump

Shown with steam pistons at mid-stroke, rockers *A* and *B* square with piston rods, steam valve placed central over ports and lost-motion nut *a* central between jaws of steam valve.

and from a change in head pressure. When regulation of the cushioning is not provided for, as is the case with most small pumps, nothing remains but readjustment of the valve gear.

If new piston rods have been provided or if the "spools" which are clamped or keyed to the rods for moving the rocker arms may have become moved, the first step would be to locate the spools to bring the rockers square with the rods when each steam piston is in the middle of its stroke. For this purpose the packing should be removed from the piston-rod stuffing boxes and the glands should be screwed up tightly. The outboard cylinder heads being removed, the steam pistons should be pushed up solidly against the inside heads. Then a line should be scribed on each rod flush with the faces of the water end glands or gland nuts. The heads of steam cylinders should then be replaced, and with the heads of the water cylinders removed, the water pistons should be pushed into the cylinders until the steam pistons are brought up solidly against the outboard heads of the steam cylinders, and each rod be scribed at the face of the same glands as before.

Then make another mark on each rod halfway between the marks and move the pistons back until the middle marks come even with the faces of the glands

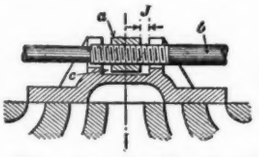


Fig. 2—Inside fixed lost motion

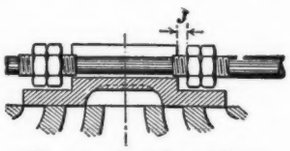


Fig. 3—Inside adjustable lost motion

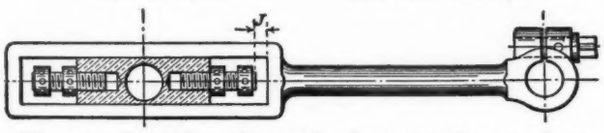


Fig. 4—Outside adjustable lost motion used on large pumping engines

from which the first marks were made on the rods. This places the steam pistons at mid-stroke between the striking points. The spools or crossheads then should be slipped along the rods until the rocker arms stand square with the rods, as shown in Fig. 1, and with the rockers in that position the spools or crossheads should be set firmly on the rods.

Next remove the steam-chest cover and place the slide valves exactly in the center over the steam ports, when for each valve the valve-stem lost-motion clearance should be the same for movement of the rocker in either direction without moving the valve.

Figs. 1 and 2 show how the clearance is obtained in small pumps. A valve rod nut *a* is placed on the rod *b*, the nut being thinner than the space *c* between the jaws of the valve. There should be the same clearance *J* on each side of the nut. If there is not the same clearance on each side, remove the rocker pin from the end of the valve stem shown at *V*, Fig. 1, and with the valve central over the ports, screw the valve rod through the nut until the eye on the valve-rod head can be brought in line with the eye of the link from its rocker *A*, Fig. 1; slip the valve-rod head pin in place and the valve is set. With this type of lost motion-adjustment the total amount of lost motion is fixed and cannot be changed except by inserting a nut of different thickness.

Fig. 3 shows a method of equalizing and also adjusting the amount of lost motion *J* without disturbing the connections outside of the steam chest, and Fig. 4 shows a method of equalizing or adjusting the lost motion where clearance is adjustable by a lost-motion link outside of the steam chest. With lost motion obtained as shown in Figs. 3 and 4, the total lost motion of the former setting should be gaged before making any adjustment, and this should be equalized to give the same clearance *J* at each end when the valves and rockers are central.

When the clearances have been equalized, and before closing up the steam chest, move one of the valves to one side as far as it will go, so the pump may be started when steam is admitted to the steam chest.

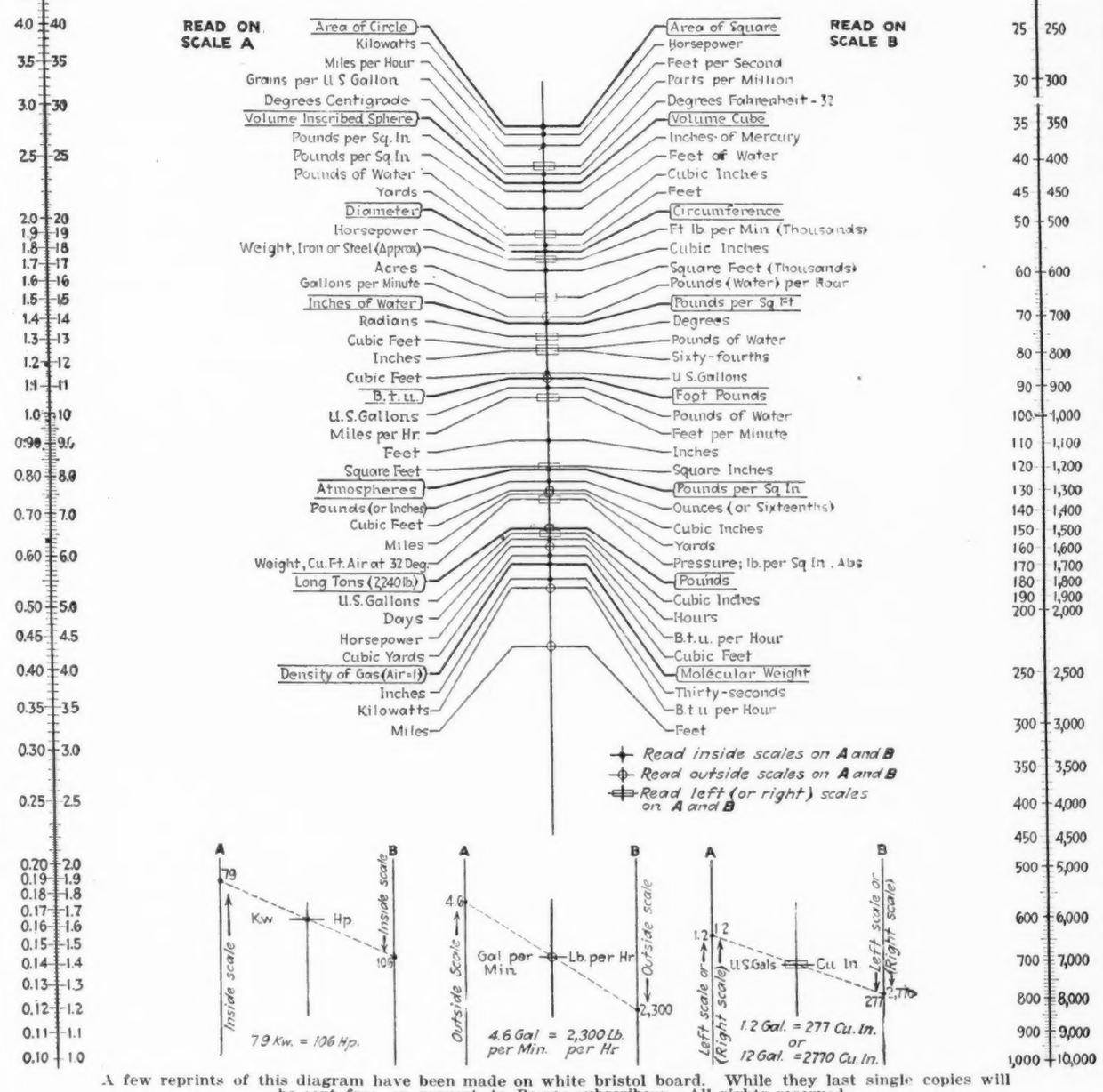
Engineering Conversion Chart

Designed by P. W. Swain, Assistant Editor of *Power*

THIS chart, which is a companion to the English-metric conversion chart published in the Sept. 4, 1923, issue, can be conveniently used to change a quantity expressed in one engineering unit to a corresponding unit. The chart will save much time in problems of this sort where an accuracy of one per cent (the practical limit in reading scales of this size) is sufficient, as is frequently the case. The method of solution is shown by the three key sketches at the bottom of the page. In order to have the decimal point come out correctly, it is necessary to read the scales on the sides indicated by the symbols (small black circle, large open circle, and rectangle) on the center line. Any straight edge may be used, but the most effective is made by scratching a straight line on the under side of a thin sheet of celluloid (photo film will do). For the greatest convenience this scratch should be blackened with drawing ink and barely perforated at the center by a needle point. A fine needle mounted in a handle may then be used to pivot the scratch about any desired point on the central scale. Where no other straight edge is available, a thread, held taut, may be used to read the chart.

If the given quantity lies outside the limits of the scale, shift the decimal point the necessary number of places before entering the chart. Then shift the point in the answer the same number of places in the opposite direction. As an example take the problem: 7,900 kw. = ? hp. Shift point two places to left to give 79 kw., which diagram shows is equal to 106 hp. Shift point back two places to right, giving 7,900 kw. = 10,600 horsepower.

If desired, additional points may be located on the central scale by solving one problem longhand with the given units, connecting the corresponding values on scales *A* and *B*, with a straight-edge and marking and labeling the point where the straight-edge crosses the middle line. To avoid confusion with present markings such new points, with their titles, may be entered in red ink.



A few reprints of this diagram have been made on white bristol board. While they last single copies will be sent free, on request, to *Power* subscribers. All rights reserved.

Operation of Electric Elevator Machines—General Principles

By F. A. ANNETT*

EXPLAINS the operation of semi-magnetic controlled elevators, describes the different automatic stopping devices and tells how to adjust the terminal landing limits.

ELEVATORS, even when defined as devices for lifting persons and materials in a vertical direction from one level to another, are by no means a modern invention, for it is a matter of record that Archimedes, over two hundred years before the beginning of the Christian era, built an elevator. This device, although operated by man power, was not dissimilar in principle to the drum-type electric elevators

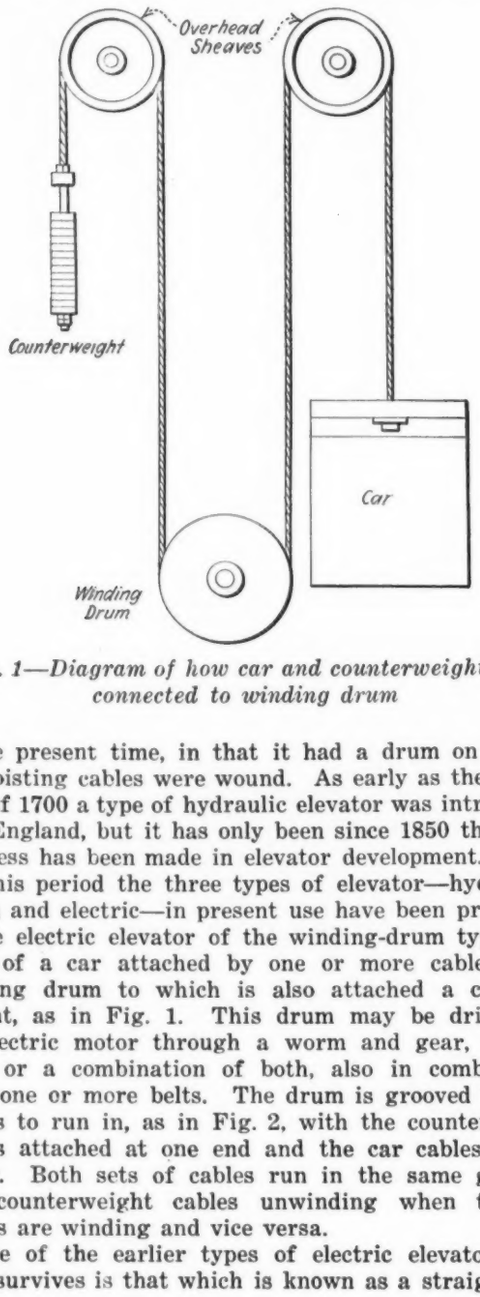


Fig. 1—Diagram of how car and counterweight are connected to winding drum

of the present time, in that it had a drum on which the hoisting cables were wound. As early as the latter part of 1700 a type of hydraulic elevator was introduced into England, but it has only been since 1850 that real progress has been made in elevator development. During this period the three types of elevator—hydraulic, steam and electric—in present use have been produced.

The electric elevator of the winding-drum type consists of a car attached by one or more cables to a winding drum to which is also attached a counterweight, as in Fig. 1. This drum may be driven by an electric motor through a worm and gear, a spur gear or a combination of both, also in combination with one or more belts. The drum is grooved for the cables to run in, as in Fig. 2, with the counterweight cables attached at one end and the car cables at the other. Both sets of cables run in the same grooves, the counterweight cables unwinding when the car cables are winding and vice versa.

One of the earlier types of electric elevators that still survives is that which is known as a straight-and-crossed-belt machine, shown in Fig. 3. In this type the motor is belted to a lineshaft, which has a wide pulley on it, connected to idler pulleys *A* and *B* on the elevator machine by a straight and a crossed belt. The motor is either started by hand and allowed to run continuously or it is started and stopped automatically from the elevator platform by pulling on a cable. After the motor is running, the elevator is started by pulling on the operating cable in the car, which in turn operates a belt-shifting mechanism through the shipper wheel *S*. This shifts either the crossed or straight belt to the driving pulley *C*, which is keyed to the wormshaft of the machine. Shifting the straight belt to the driving pulley gives one direction of motion to the car, while shifting the crossed belt to pulley *C* imparts the opposite direction. With this type of machine the motor always runs in the same direction. There have been a great many different arrangements of this type of machine developed, both for operation from the power lineshaft along with the rest of the machines of the building or from an individual motor, as explained in the foregoing, but they all involve the same principle.

The machine shown in Fig. 3 is arranged for ceiling mounting, while the type, Fig. 4, is intended for floor mounting. Fig. 4 indicates clearly the belt-shifting

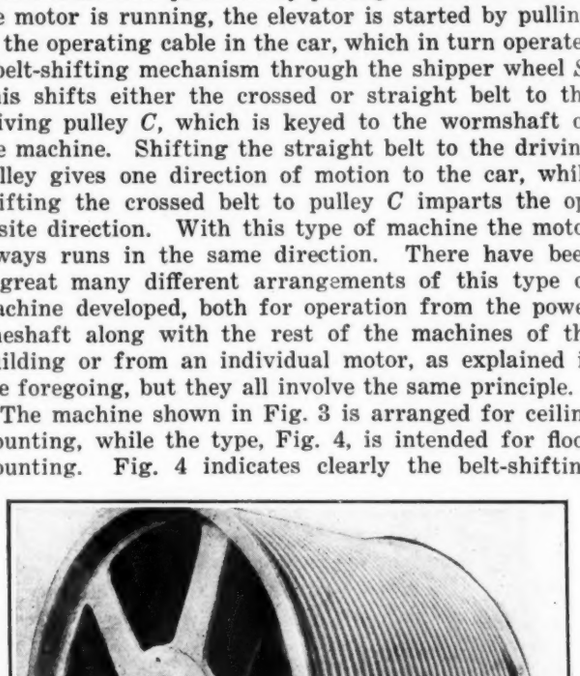


Fig. 2—Winding drum of elevator machine

mechanism and how it is operated from the shipper wheels *S*. Rollers *O* and *O'* are attached to the shipper-wheel rim and mesh into the forked castings *G* and *G'*. Casting *G* is attached to rod *J* and *G'* to *J'* by set-screws. When the shipper wheel is turned in a clockwise direction, roller *O'* engages the fork *G'*, moving it to the left and with it rod *J'* and the belt shifter *K'*, which would move the belt off idler pulley *A* onto tight pulley *C* and start the elevator machine in a direction corresponding to the motion of the shipper wheel. When the operating cable is pulled to its central position to stop the car, this will bring the shipper wheel to

*Assistant Editor of *Power*.

the neutral position, as shown in the figure. Pulling the operating cable so as to turn the shipper wheel in a counterclockwise direction would cause roller *O* to move fork *G* to the right and with it belt shifter *K*, which will move the belt off idler pulley *B* onto the tight pulley *C* and impart opposite direction of motion to the elevator.

A step in the direction of the modern drum-type elevator was to do away with the lineshaft with its

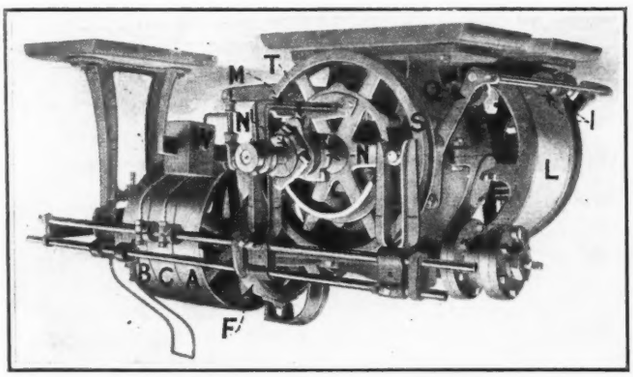


Fig. 3—Belted-type elevator machine for ceiling mounting

straight and crossed belts and belt the motor directly to the driving pulley on the wormshaft. This involved providing a control for the motor that would not only start and stop it automatically, but also reverse it so as to give the elevator a direction of motion corresponding to the position to which the operating cable in the car was pulled. The same principles that prevailed in this belted-type elevator are also those in the modern drum-type machine. In the latter type the motor winding drum, worm and gear are mounted on the same bedplate, with the motor coupled directly to the wormshaft, as in Fig. 5.

Elevator machines may be grouped into two general classes, semi-magnetic controlled and full-magnetic controlled. The semi-magnetic controlled machine is operated from a rope running through the car or from a lever or a handwheel attached to the operating rope. This operating rope is attached to the shipper wheel on the machine which is revolved in a direction corresponding to that in which the hand rope is moved. Attached to the shipper wheel or to the shaft on which the shipper wheel may be mounted, is a connection to the motor controller. According to the direction in which the shipper wheel is moved, the reverse switch on the controller is closed to a position to give the proper direction to the motor. The brake may be either mechanically or electrically operated. With the machines shown in Figs. 3 and 4 the brake *F* is mechanically operated. A cam *H*, Fig. 4, mounted on the inside of the shipper wheel, presses against a roller *R* in the lower end of bell crank *D*, which is attached to the brake lever at *E*. As the lower end of the bell crank is moved to the left, the end attached to the brake will be raised and with it the brake lever and weight *W*. This movement expands the brake band *F*, releasing the brake wheel, and leaves the machine free to be operated by the motor.

At the top and bottom landings the machine is stopped automatically. Where a mechanically operated brake is used, as in Figs. 3 and 4, and the operating cable runs through the car, automatic stopping at the top and bottom landings may be accomplished in two ways. The first is by placing stop balls on the operating cable at places where they will be hit by the car as it approaches the terminal landings and move the operating mechanism to the central position similar to the way it would be done by the operator. The other method of stopping the car automatically is by the drumshaft limits. These limits consist of a traveling nut *T* and two stationary nuts *N* and *N'*, shown on the end of the drumshaft, which is threaded, Figs. 3 and 4. The traveling nut *T* engages the shipper wheel through a casting *M*, which has a tongue on its inner surface that fits into a groove in the end of *T*. On each side of *T* is a lip that, when the car reaches the top or bottom landing, engages a similar lip on the inside of nut *N* or *N'*. With this arrangement the winding drum *L* must turn in an opposite direction to that in which the shipper wheel is turned to start the car.

For example, if the shipper wheel was turned in a clockwise direction the drum would have to turn in a counterclockwise direction for the proper operation of the elevator machine. In doing this with a right-hand thread on the end of the drum shaft, the traveling nut *T* would be caused to move toward stationary nut *N*, which, if properly adjusted, will be engaged by *T* when the car approaches near the bottom landing. When this occurs, the shipper wheel will be turned in a counterclockwise direction and brought to a neutral position and the elevator stopped by applying the brake. If nut *N* is adjusted to the proper position, the car will be stopped level with the bottom landing. When the car comes to the top landing, a similar operation takes place when *T* engages *N'*. In this case, however, the drum is turning in a clockwise direction and the shipper wheel was turned in a counterclockwise direction to impart this direction of motion to the car. Therefore when *T* and *N'* engage, the shipper wheel is

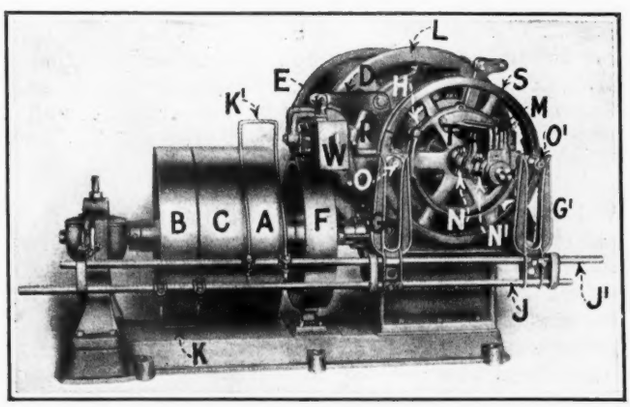


Fig. 4—Belted-type elevator machine for floor mounting

turned in a clockwise direction and brought to the neutral position.

Adjustment of the limits is made by first adjusting the stop balls on the operating cable so that the car will stop at the top and bottom floor with full load in the car with the brake properly adjusted. After this has been done, the nuts *N* and *N'* on the drumshaft are adjusted so that they will stop the car in practically the same position as the stop balls. The drumshaft limits should be set slightly behind the stop balls on the operating cable, so that in case these balls slip or the operating cable breaks or becomes fouled in the

sheaves, the drumshaft limits will bring the car to rest at the terminal landings.

Where the machine is operated from a handwheel or a lever in the car, the only limits to stop the car at the terminal landings are those on the drumshaft. On machines with an electrically operated brake, as in Fig. 5, a third method of limiting the travel of the car at the terminal landings is made available by open-

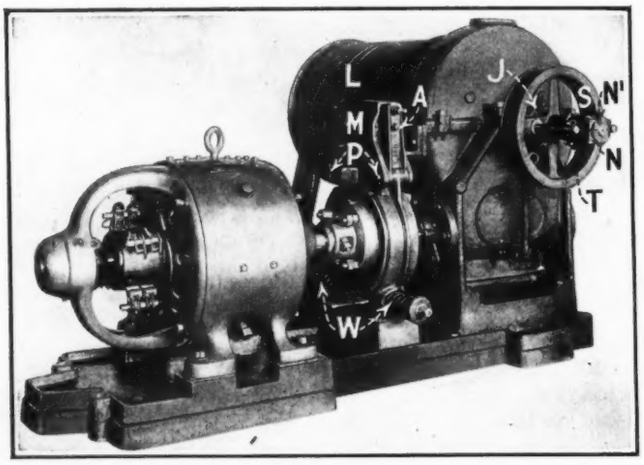


Fig. 5—Drum-type elevator machine with motor mounted on same bedplate

ing the line switch and cutting the power out of the machine entirely. This is done by placing a switch at the top and another at the bottom of the hatchway so that they will be opened by the car in case the latter goes by the terminal landings. Opening either one of these switches interrupts the circuit to the holding coil on the main-line switch, which causes it to open and cut the power out of the motor. The opening of this switch also opens the brake-magnet-coil circuit, which allows the brake to be applied and the machine stopped. With a mechanical brake it would be of no use to cut the power out of the motor unless the brake was applied, as the machine would probably keep in motion and control of it might be lost entirely, with serious consequences.

Operation of Brake Mechanism

With the machine shown in Fig. 5 the brake is released by the magnet *M* pulling in two cores attached to an extension of the brake shoes at *A*. The brake shoes are fulcrumed on the pins *P* and are applied to the brake wheel by springs *W*. This machine has a shipper wheel *S* on the end of the drum shaft to which the operating cable running to the car is attached as in Figs. 3 and 4. It is also equipped with the drumshaft limits *T'*, *N* and *N'*. The controller for the motor is attached to the shipper wheel by a chain that runs on the sprocket wheel *J*.

There is one other safety device on the semi-magnetic controlled elevator machine, and that is the slack-cable limit. Where the elevator machine is equipped with a mechanical brake, as in Fig. 3, this safety device is mechanical in its operation. The car-hoisting cables come off the winding drum *L* and pass up the hatchway against the small sheaves *I*. While the cables are taut, the framework *Q* is held up in the position shown. Should the cables become slack, due to the car safeties setting on the guide rails or to the car striking the bumpers in the bottom of the hatchway, the framework will be allowed to drop and in doing so will throw in a clutch on the back of the shipper wheel. This clutch connects the drumshaft to the shipper wheel and causes the motion of the drum to bring the shipper wheel to the off position in the same manner as the drumshaft limits will at the terminal landings. Where the machine has an electrically operated brake, the slack-cable device generally consists of a bar that runs across the bottom of the drum. This bar is attached to a switch, known as the slack-cable switch, in series with the coil on the main-line switch holding coil. Should the cables become slack for any reason, they will strike the bar and open the slack-cable switch, which in turn opens the main-line switch and causes the elevator machine to be stopped.

Method of Driving Winding Drum

In all three machines, Figs. 3 to 5, the winding drum *L* is driven by a worm and gear, the drum being keyed or bolted directly to the gear-wheel and shaft. With the machine Fig. 6, the gearshaft has a spur gear keyed to it which in turn meshes into an annular gear on the winding drum, thus giving two reductions in speed from that of the motor. This arrangement allows a slow speed on the drum with a high-speed motor.

In the machine Fig. 6 the shipper wheel *S* and limits are not mounted directly on an extension of the worm-gear shaft, but on a short shaft mounted at right angles to it. These two shafts are connected by beveled gears *U*. On the end of the operating shaft is an eccentric *E* which releases and applies the brake through rod *W*. Part of the slack-cable device is under the drum and arranged so that, should the cables become slack, clutch *R* is thrown into mesh with the shipper wheel through rod *I* and causes the machine to stop.

A full-magnetic controlled elevator machine is one

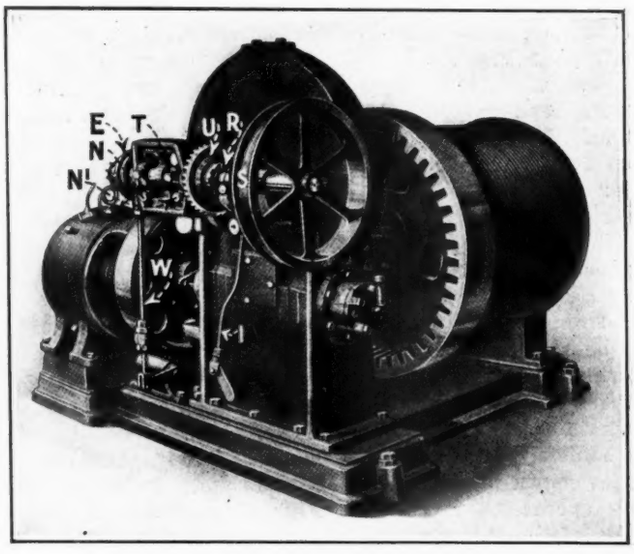


Fig. 6—Internal-geared drum-type elevator machine

that is started and stopped from a switch in the car. In this way all operations of the control equipment are made electrical. Although full-magnetic control makes possible many refinements in elevator operation that cannot be obtained with semi-magnetic control, the general principles are the same as those described for the semi-magnetic controlled machine.

Applying Centralized Control to Steam Heating Systems

TELLS how central-station steam was supplied to an office building and what arrangements were made for heating a factory where public-utility power had supplanted that from a private plant.

INDIVIDUAL radiator adjustment, whether of the type employing full valve opening and complete closure, or that of the fractional valve opening by which the steam may be conveniently modulated, has been reported widely as being wasteful in actual operation, as in moderate weather windows are frequently opened in preference to turning off radiators. With automatic individual control this practice also tends to produce excessive radiation. Manual control under any circumstance is limited in efficiency by the operator or tenant so that excessive steam supply is characteristic of warmer outside temperatures, when regulation is most necessary. In providing a cooling period at night, individual control has proved inferior to a centralized system, where the quantity of steam supplied may be accurately adjusted by a reliable man or by automatic means. The average steam-heating equipment, in spite of its possible record for satisfactory operation, is usually subject to greater improvement with regard to economy than any other familiar type of mechanical apparatus. Being designed to meet the requirements of the coldest weather, it is not adequately equipped, as a rule, to operate efficiently at moderate outside temperatures.

Fig. 1—Steam supply regulated according to outside temperature

Improved service and a possible saving in steam were the motives in revamping the system of an office building. Because of improper distribution and pockets in some of the piping it was not possible to obtain good circulation through all the radiation when the pressure was reduced a considerable amount. High pressure at the supply point therefore was necessary in order to eliminate complaints of this character with the result that there was overheating much of the time in the other parts where good circulation normally obtained. The steam bills were undesirably high since a greater amount of heat was being utilized than was actually required.

The original heating equipment consisted of a two-pipe down-feed system supplied from boilers in the building. The main supply riser ran to the top of the building on the west side and distributed around the top floor to various down feed risers, as indicated in Fig. 2. The original boilers had been abandoned several years before in favor of steam supplied from a central heating plant, at a pressure of 100 lb. The total radiation was 3,800 sq.ft. A restaurant in the basement utilized this high-pressure steam for cookers; the heating for this part of the building, being separate from the main system, was not changed.

The type of heating control to be installed included a special flow control chamber placed at the point of supply to measure the input steam, together with a special hand valve for adjusting this to the exact amount required, in accordance with the demands of outside temperature. In Fig. 1 is shown the gage

board, with gages for the pressure applied on the incoming side of the flow meter, the pressure at the delivery side of the meter, and also a recording device for flow-meter pressure and outside temperature. Several systems of this general type were described in the Oct. 2, 1923, issue.

The first step in applying centralized control was to make a detailed survey of the building. The wall and glass areas were carefully gone over in comparison with the exposure of the building, and the total installed radiation checked, the heating coils being found sufficient in each case. The total amount of steam that would be required for the maximum heating demand was determined, from which was figured the necessary amounts required for intermediate heating loads in order to provide a chart of pressures for operation, as in Table I.

Orifices then were placed in each down-feed riser so that the correct relative proportion of steam would be received. The inlet valve of each radiator was also equipped with a control orifice disk, the entire system being calculated so that steam in proper relative amounts would reach each radiator uniformly, under all conditions of operation.

With this system of control the entire radiator is heated in cold weather, while only varying portions of

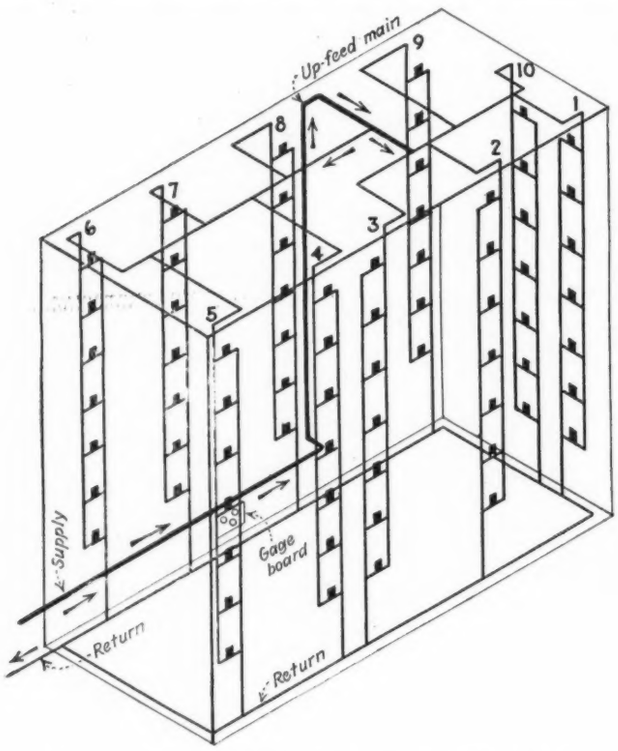


Fig. 2—Two-pipe down-feed system adjusted for uniform distribution

each are heated in warmer weather. The outlet of the radiator will be either warm or cool, depending on where condensation begins in accordance with the demands of radiation as created by outside temperature. It is evident, therefore, that overheating is practically eliminated, and the impression is soon gained by the occupants that the heating coils can be depended on without the necessity of opening the windows in mild weather.

The comparatively small amount of hand regulation that is necessary may be inferred from the charts, Figs. 3 and 4, where outside temperature is in heavier lines than that of the control chamber pressure. The cool-weather chart, Fig. 3, was placed in the meter about 6 a.m., Monday. The system was first heated up to normal at high pressure till 9 a.m., when this was re-

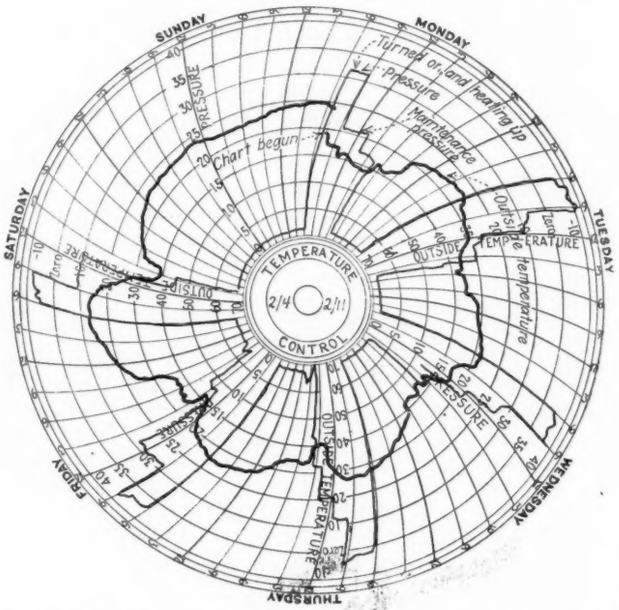


Fig. 3—Heating and cooling periods at low temperatures

duced to that nearly corresponding to outside temperature, or, to be exact, about 10 lb. more. At 1 p.m. this was reduced a few pounds, and then turned off at 5. Next day, heavier pressures were carried, but the steam was turned off at 4 p.m., as also on several succeeding days. At the end of the week the supply is completely shut off. Fig. 4 shows moderate conditions.

Three practical points are evident. Efficient operation of the system can be checked at any time by feeling the return lines or otherwise determining their temperatures. If it is desired to supply steam at night as well, a chart can be made up indicating the amount desired in accordance with outside temperature, while an even distribution will be assured. Also, the degree of comfort of the occupants does not require that supply steam be regulated at frequent intervals in close accord with outside temperatures.

As a result of the new system operation during the 1923-24 heating season indicated a reduction in steam of 16 per cent below that averaged by the three previous ones.

A different problem was presented in connection with a factory building, Fig. 5. While the idea of saving heat was primarily of interest, the increase of the workmen's efficiency, as a result of greater comfort and uniform temperature was found to be so great as to far outweigh the financial consideration of saving in steam. The amount of production by the working force depended largely on maintaining a comfortable temperature. Besides housing a factory, there were offices at each end of the building which were desired to be slightly warmer, so that when the former required 65 deg., a temperature of 70 deg. was desirable in the offices. Half of the building represented a new structure, which had been heated by extending the

main on the upper floor from the old building over into the new, and adding risers.

Heating conditions were further unsettled by the fact that central-station power had been utilized instead of that from the privately owned plant, so that the supply of exhaust steam was greatly reduced and live steam

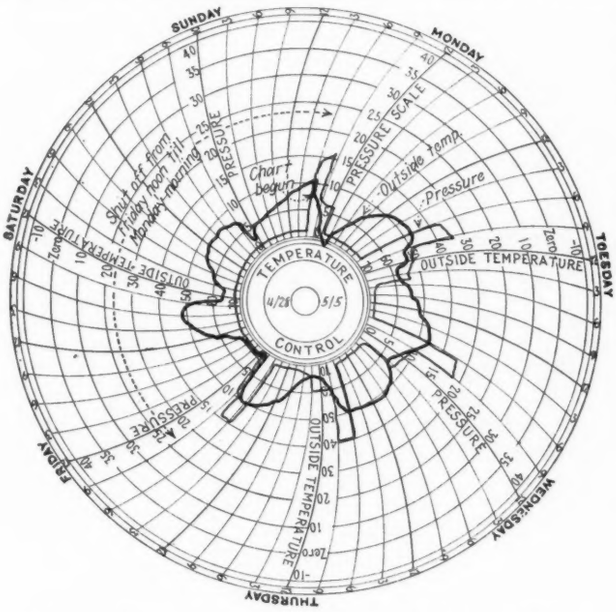


Fig. 4—Steam adjustment for moderate conditions

was necessary in a large amount for supplying heating. The building, indicated in Fig. 5, contained approximately 9,000 sq.ft. of radiation, supplied by a two-pipe down-feed system, the building at the right beyond the

TABLE I—CONTROL-CHAMBER PRESSURES FOR OFFICE BUILDING

Nozzle pressure.....	35	31	28	24	21	17	13½	10	7	5	3	2	1
Outside te mperature	0	5	10	15	20	25	30	35	40	45	50	55	60

dotted line representing a new addition. Offices were located at each end of the building.

The system had originally been supplied by exhaust steam from a private plant consisting of two boilers, 1,250 sq.ft. each, a Corliss engine, two duplex pumps and a deep-well pump. With central station power very little exhaust steam was available, representing

TABLE II—NOZZLE PRESSURES AND LIVE STEAM FLOW REQUIRED IN ADDITION TO EXHAUST STEAM FOR FACTORY

Outside Temperature	Nozzle Pressure	Computed Steam Flow, Pounds Per Hour Main Office	Factory	Griffin White Off.
0	27	330	2,550	60
5	24	306	2,368	55.7
10	21	283	2,186	51.4
15	18	259	2,004	47.1
20	15	236	1,821	42.9
25	11	212	1,639	38.6
30	9	188	1,457	34.3
35	7	165	1,275	30
40	5	141	1,093	25.7
45	3½	112	910.7	21.4
50	2½	94.2	728.5	17.1
55	1½	70.6	546.4	12.9
60	1	47.1	364.3	8.6

that from the pumps, so that the heating was largely provided with live steam.

A survey was made of the building and equipment, including the steam required, amount of radiating surface, distribution of radiation, defective piping, etc. It was found that some parts of the building heated readily and in others the circulation was poor, as in the previous example. Since the radiators were hand controlled, employees occasionally forgot to turn off the steam at night, with the result that some sections of the building would be overheated next morning and others exceedingly cold. Sickness was frequent as a result.

In proportioning the riser and radiator orifices for the purpose of distributing steam, it was decided to place a valve at the top of the down-feed risers Nos. 1 and 7 at each end of the building, which supplied the office section. The bottoms of these supply risers were connected independently to the steam supply, so that the central control if desired could be made to operate only the remaining risers which supply the factory. In cold weather, where large amounts of steam were required, it was satisfactory to leave the valves on risers Nos. 1 and 7 open, so that the office sections could be supplied through the main central point. In moderate weather, however, these valves could be closed and steam turned off from the factory section if desired, while radiation could be supplied to the offices independently of the main control.

The control apparatus in this instance was of the same general type as before. Table II shows the amounts of live steam that must be admitted in addition to the exhaust for various outside temperatures.

During the heating season of 1923-24 the desired degree of comfort was obtained, with the elimination of much of the sickness previously encountered. The effect on factory production was so satisfactory as to

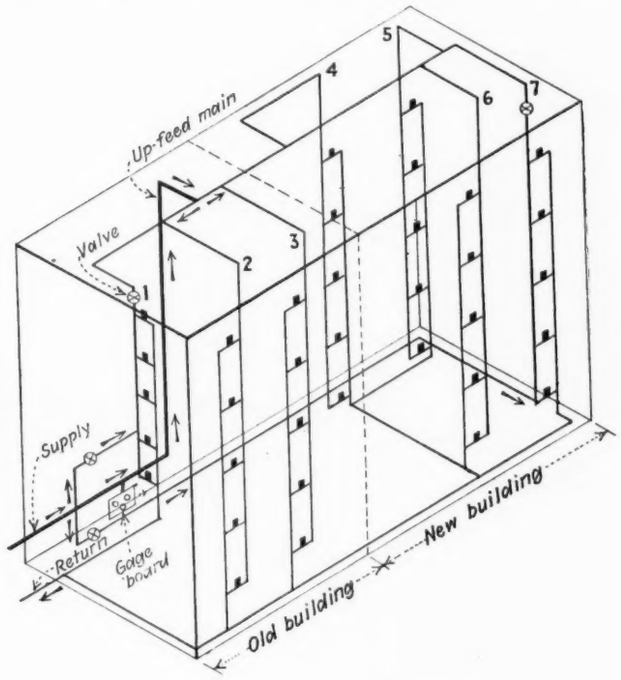


Fig. 5—Heating system supplied by pump exhaust and central station steam

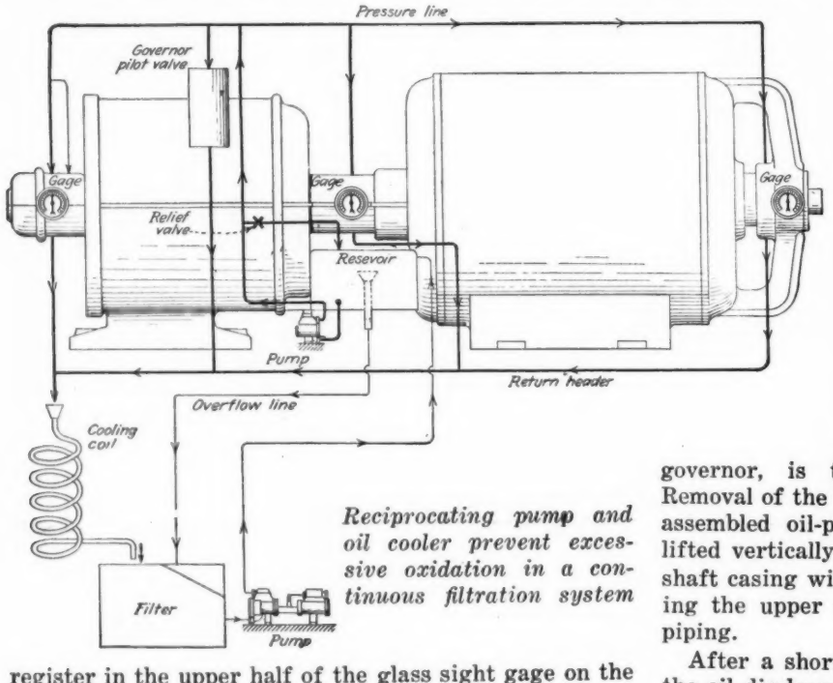
outweigh considerations of steam economy. It was found, in this instance, that coal supplied to the boilers was in the neighborhood of 30 per cent less than that of the average of the previous heating season. This is a rough way of measuring the gain, as the power plant had been shut down during both periods. About 25 per cent of the total fuel used represented scrap from the factory, which was not measured, although it was estimated to be about the same in each instance.

Improving the Lubrication System of Steam Turbines

By CLAUDE C. BROWN

Describes oil troubles, their causes in steam turbines, and how the application of a cooling coil and a slow reciprocating steam pump eliminated them from a continuous filtration system.

SOME interesting points have been developed in connection with an installation of four 1,500-kw., 3,600-r.p.m. turbines in the plant of a Western sugar refinery. The lubrication of these turbines is accomplished by means of a forced feed system. The bottom of the connection frame between the steam turbine and the generator of each unit is used as a reservoir in which the oil level is maintained so as to register in the upper half of the glass sight gage on the side.



Reciprocating pump and oil cooler prevent excessive oxidation in a continuous filtration system

Each unit is equipped with an oil pump, consisting of two spur gears in mesh revolving in a casing below the oil level in the reservoir. One of the gears is driven by the governor shaft, which makes one turn for each six turns of the main turbine shaft through the medium of a worm-gear connection. The oil pump draws oil through a suction strainer cap of fine-mesh screen, which is removed and cleaned once a week by removing the handhole plate in the side of the oil reservoir. The discharge oil pressure is maintained at about 25 lb. pressure by the proper setting of the relief valve on the oil discharge line, which returns the excess oil to the reservoir.

The mainshaft bearings, in addition to being ring-oiled, are supplied with oil under pressure from the pump. The pressure must at all times exceed that at which there is any tendency for the shaft to break down the oil film. With the usual conditions it has been found that 25 lb., as registered on the gages at the bearings and adjusted by means of the feed valves at each bearing, is sufficient. A separate oil feed line from the pump discharge furnishes lubricating oil to the thrust bearing of each machine. Oil leakage along the turbine shaft from the bearings is preventel by fan deflectors attached to the shaft at locations close to the inner surfaces of the bearing housings. The housings are vented to carry off air and oil vapor pressure during operation.

After the lubricating oil has passed through the bearings of the machines, it is collected in a return header as shown in the figure, entering the latter through a sight funnel from each machine, and dropped by gravity into a filter on the basement floor. In the original installation the oil was drawn from the storage tank of this filter and pumped up to the turbine reservoirs on the floor above, by means of a small centrifugal pump.

At periodic intervals of one month the oil pump is disassembled for inspection and cleaning. This is done by disconnecting the governor lever and unbolting the top half of the connection piece at the turbine and generator flanges. The bolts are then removed from the governor shaft casing at the middle bearing cap, and all small piping is taken off. The top half of the connection piece, with the governor, is then removed with a straight lift. Removal of the bearing cap exposes the driven gear and assembled oil-pump parts. The pump shaft is then lifted vertically through the worm gear, and the pump shaft casing with the oil pump is removed after unbolting the upper flange and disconnecting the discharge piping.

After a short period of operation it was found that the oil discharged by this centrifugal pump was overly warm and greatly aërated, a condition that is very undesirable for the reason that it tends to oxidize the oil. As a result of investigation the centrifugal pump downstairs was replaced by a small reciprocating steam pump and a cooling coil, consisting of some 75 ft. of 1½ in. copper tubing immersed in a wood tank of circulating sea water, installed, after which no further difficulty was encountered. In the design of the circulating oil system for these turbines liberal allowance was made in the pipe sizes of all the lines, so that no difficulty is met in handling the oil so far as capacity of pump, lines, etc., is concerned.

Experience has shown that the lubricating oil giving the highest satisfaction as a lubricant in this circulating system is a pure hydrocarbon oil, free from tarry, slimy or saponifying elements, acids, soaps or thickeners and also free from water, dirt, grit or other suspended

foreign matter. The flash point of this oil as shown by an open cup tester is above 300 deg. F., and the viscosity as determined by the Saybolt 40 deg. C. viscosimeter is less than 228 sec. A very essential quality of this oil is its incapability of forming an emulsion with water.

When the turbines were first started in operation, the lubricating system was filled with a well-known medium-heavy turbine oil. After a few weeks of operation the oil and all of the bearings as well, began to heat up badly. One of the machines was taken down and the bearings examined in an effort to locate the trouble. Upon removing the bearing caps, the entire linings of the bearings, as well as the interior of all of the circulating oil system, pump, strainers, etc., were found to be covered or partly covered with a hard black coating. This was found to be oxidized oil, and it was necessary to shut down all the machines and scrape it out The entire first filling of oil was discarded and a higher grade put in, that met the foregoing specifications, after which satisfactory results were obtained.

Dark Color and Acidity Show Oil Deterioration

The circulating system for the lubrication of the turbines at the refinery in question contains a charge of six barrels of oil. It has been found that owing to the careful attention given the system, to the absence of serious aëration of the oil and leakage of water into the system and to the low bearing and oil temperatures maintained, the waste or leakage of oil from the system is small. The quantity of makeup or fresh oil added to the system is therefore correspondingly small, and the life of the oil, or rather its length of service, is great. It is standard practice at the plant in question to add one-half barrel of fresh medium-heavy turbine oil to the system at periodical intervals of one month after first drawing off the same quantity for settlement, filtration and re-use. If, however, any loss of oil occurs during the interval, sufficient new oil is added to make up this loss. There are two danger signals that may serve to warn the operators of oil oxidation or breakdown, one of which is the sudden darkening in color of the oil and the other the formation of petroleum acids.

The lubricating oil used in the modern turbine systems where forced to the bearings under pressure, collected, filtered, cooled and repeatedly returned to perform the same severe service, is subjected to considerable strain. As a result, deposits frequently form due to the breaking down of some portions of the oil from the effects of heat, air, water, solid impurities, foreign substances, broken-down oil, or at times even the addition of new oil to the system.

Entrained Air Causes Black Deposit

The oil in the circulating system always contains more or less air which is collected in its journey through filters, coolers, sight funnels, pumps, etc., and when the temperature of the oil is above normal, higher than about 140 deg. F., this entrained air has a decided tendency to oxidize the oil. This is particularly true in the bearings where the film of oil is extremely thin and the air is present in the form of very fine bubbles which are intimately mixed with the oil. The result of this oxidation of the oil by the entrained air is a decided darkening in color and a loss of "body" and lubricating qualities. In aggravated cases a dangerous black carbon deposit is thrown down, which may choke the oil inlets to the bearings and cause the oil-operated pilot valve of the governor to stick.

Where ordinary oils are used in the circulating system, the comparatively high temperature at which the oil passes through increases to a great extent the oxidizing effect of solid impurities such as dust, dirt and iron oxides. The results produced by this oxidizing effect are a decided darkening in color of the oil, a decided increase in viscosity, the breaking down of a portion of the oil and the formation of petroleum acids. Under these conditions the oil smells burnt and deposits a slimy coating which lodges in the system, most noticeable on the inner surface of the cooling coils. If, in addition to the impurities mentioned, there is a slight amount of water present in the oil, the latter will tend to emulsify owing to its broken-down condition. Oftentimes when a turbine is started up for its initial run the oil will emulsify due to the combined effects of air, grit and water even though it is of a very high grade.

Pump Suctions Far Above Water Level

Water may get into the oil circulating system through steam leakage of the gland packing, from the water jackets in the housings of the main bearings, from the water-cooling system or from other causes. If a considerable quantity of water is present in the oil system, emulsification will take place and the mixture becomes yellowish brown in color. This emulsification, if allowed to continue, will form a hard mixture which tends to clog up the system. In order to reduce the possibilities of water being carried into the bearings of the turbines, the oil pumps in each unit are set so that the suction strainers are four inches above the bottoms of the oil reservoirs, and the latter are provided with drain cocks by means of which the water, if there is any, is drawn off at periodic intervals. In the same manner the suction of the pump that draws the oil from the storage space of the filter is set well above the bottom of the filter tank.

It has been found to be good practice to keep the temperature of the oil returning from the bearings below 130 deg. F., and this is done by varying the oil feed to the bearings and the velocity of the circulating water in the oil cooler. Thermometers are located at all bearings, and a log record is kept of readings taken at half-hour intervals.

Oil Temperature Constant in Fifteen Hours.

It has been found that after these turbines are started running, the temperature of the oil gradually increases and finally becomes constant in approximately fifteen hours' running. The heat is transferred to the oil from different sources. In the first place the turbine shaft becomes heated by the steam in the turbine casing. This is conducted along the shaft and, together with that generated in the bearings, is there transferred to the lubricating oil. Most of the heat absorbed by the oil is removed by the circulating water around the cooling coils. The resultant constant temperature depends to a certain extent upon that of the cooling water, but to a greater extent upon the capacity and size of the coils in the oil cooler. The larger the size and capacity of the cooling coils, the lower will be the temperature of the oil.

At certain times it has been noted that atomized oil or oil vapor comes from the bearings and oil tanks. This occasionally occurs at times when the temperature of the oil is well within the limit of good operation. The cause of this phenomenon is the aëration of the oil. the

latter being charged with tiny air bubbles. When the bubbles burst in the bearings or in the oil tanks, the vapor is produced from the resulting fine spray of oil. This condition is very undesirable for the reason that aëration of the oil has a strong tendency to oxidize it and break it down. There is also danger of the fine oil spray being drawn into the windings of the generator, carbonizing thereon and causing trouble. Every precaution should be taken to prevent the oil from becoming aërated, by eliminating any pump churning action or splashing of the oil in the system. The main bearings of these turbines are all vented for the purpose of removing any oil vapor that may be formed in the bearings, as are the reservoirs and filters. Foaming may sometimes occur in the lubricating system due to the aëration of the oil, and is sometimes caused by the addition of too great a percentage of new makeup oil being added to the system. Continued foaming indicates that there is an air leak into the suction of one of the pumps, and it should be remedied as soon as possible.

Sufficient Storage Capacity to Allow Settling

The length of life, or rather the length of continuous hard service that a lubricating oil will give, depends upon the grade or quality of the oil, and upon the treatment that is accorded it. A properly chosen grade and quality of oil, used under the average conditions obtaining in the modern oil circulating systems, properly filtered and cooled, should have a useful life of 10,000 working hours. Where conditions are very severe and unfavorable and where the oil is not properly taken care of, the life of even the best grade will probably not average 3,000 working hours.

High-grade oils that are manufactured for the purpose of turbine lubrication systems, are specially treated to produce ready and easy separation and to withstand contamination with impurities under the trying conditions of severe service. When the operating conditions are especially severe and impurities collect in the circulating system, the oil picks up these impurities and conducts them to the bearings, where they may cause corrosion of the bearing metals.

It is said that the most prominent failures in turbine lubricating systems have been in turbines of high-speed design where the surface speeds of the journals was consequently high, and where the circulating rate of the lubricating oil in the system was too high to allow the water in the oil to settle out. A very important factor in the successful operation of any oil circulating system is that the design should provide adequate and unstinted oil storage space and filtering facilities so that the oil may be brought to rest for an appreciable length of time, thereby giving it a chance to separate from the air, water, dirt, and other impurities contained in it.

Renew Oil Three Weeks After Starting

Experience has shown that when starting up any turbine circulating oil system for the first time, there is always sure to be present impurities and foreign substances of many sorts, such as metal chips, core sand, scale, cotton waste, bits of wood, grease, moisture, etc., which tend to cause trouble in the lubricating of the turbines. It is therefore excellent practice, after running the system for two or three weeks, to remove the entire charge of oil from the system and put in fresh oil. The removed oil may be heated, allowed to stand and settle, and filtered. If not broken down too badly, it may be used as makeup.

It goes without saying that it is of the utmost importance to clean out the entire oil circulating system thoroughly before any oil is originally put into it, so that the amount of the foreign matter left therein after the completion of construction will be a minimum. Even with the most thorough and painstaking cleansing of the system prior to the installation of the oil, the penetrating and cleansing effect of the hot oil will cause it to pick up and absorb impurities that cannot be removed by blowing or flushing, and it is therefore imperative that the first charge of oil should be removed and filtered after an initial run of three weeks.

Cost of Byproduct Power

The statement is frequently made that, where the exhaust steam is completely utilized, power is obtained without any cost for fuel. For all practical purposes this is correct, in that the additional fuel required is so small as to be almost negligible. Strictly speaking, there is a slight increase in fuel consumption, and it is interesting to see what it amounts to.

Suppose first that low-pressure boilers are used to supply the required process steam. Next imagine that these are replaced by high-pressure boilers and a reducing valve. If the high-pressure boilers have the same efficiency as the low, there will be no change in the fuel consumption, since the reducing valve does not remove any heat from the steam.

Next imagine the reducing valve replaced by an engine—any old engine from a unaflow to a crude slide-valve machine. The coal consumption will increase by about one-third of a pound per hour for each horsepower delivered at the shaft.

To see that this figure is practically independent of the efficiency of the engine, it is only necessary to point out that all the internal "losses" (piston friction, cylinder condensation, valve and piston leakage, wiredrawing and exhaust "loss") remain in the steam. The only heat really withdrawn from the steam is that delivered as power and a small amount going to *external* losses (radiation and the friction of moving parts *outside* of the cylinder). Each horsepower-hour requires 2,545 B.t.u. directly. As the external losses are a small fraction of this, 3,000 B.t.u. per hp.-hr. should be ample to cover everything. With 13,500-B.t.u. coal and a boiler efficiency of 67 per cent, each pound of coal burned would supply $13{,}500 \times 0.67 = 9{,}000$ B.t.u. (approximately) to the engine, so that only one-third of a pound per hour would be required for each horsepower delivered. To allow for lower boiler efficiency and eliminate all chance for argument, this figure might be increased to half a pound, an extremely conservative estimate.

Even with coal at $8 a ton this would make the extra fuel required for power generation cost only two mills per horsepower-hour. To calculate the total cost of the power, this figure should be increased by the overhead, labor, etc., on the engine and that portion of boiler-room overhead, labor, etc., corresponding to the *increase* in the coal consumption.

To show the small effect of power generation on the total coal consumption, consider a plant burning 5,000 lb. of coal an hour for process or heating steam. The generation of 200 hp. from this steam would, at the most, increase the coal consumption to 5,100 lb. per hour, a difference too small to be detected by direct measurement in every-day operation.

The N.A.S.E. Program

THIS year's program of the National Association of Stationary Engineers' convention at Grand Rapids marks a departure from previous years by the inclusion of a group of excellent technical papers by specialists in their respective fields, an accomplishment for which the committee is to be congratulated. How well the papers are received will indicate whether the Association is ready to follow the ideals for which President Holbrook has labored untiringly for the last twelve months.

Too often the national convention is looked upon as an occasion for a good time and the renewal of old friendships; a pleasant anticipation to be sure, but one hardly calculated to enrich the knowledge of the returning delegate. If less time were devoted to routine business matters that could better be settled by committees and more time devoted to engineering subjects, there would still be opportunity for social activities at the convention.

There is no reason why the N.A.S.E., in matters pertaining to the operating field, should not rank with other national engineering societies in their respective technical fields, and make its annual conventions occasions for the dissemination of authoritative information on operating practice.

A Maintenance Plan Should Be Thought Out in Advance

THAT time-worn adage, "A stitch in time saves nine," contains more truth than fiction for those who have to do with maintaining equipment. There is a general tendency to do the investigating after the damage is done, and the repairs probably cost many times what they would have done had the defect been discovered before it developed into an actual failure. Proper maintenance methods include much more than making repairs when a piece of equipment fails to function. The largest part of any maintenance job should be the prevention of trouble, but if trouble does develop on a piece of important equipment, it should be well thought out in advance how it can be met with the least inconvenience.

Because some particular motor or group of motors have operated for so long without giving trouble that they have come to be considered "old reliables," is no reason why they will continue to do so. One of the best ways of insuring their continued reliability is by a careful system of inspections. Oil or moisture may be working into the winding for a long time before giving trouble, but when failure does occur a complete new winding may be necessary. Such a repair, if not provided for in advance, means a considerable delay in getting the machine back into service. Had periodic insulation tests been made, the deterioration of the insulation would have been detected and the cause probably eliminated. On the other hand, if it were found that the machine was getting in such shape as to require rewinding, a new set of coils obtained in advance would save much of the delay in getting the machine back into service.

It may be that the equipment driven by the motor is of such importance that its failure will seriously interfere with operations throughout the plant. In this case the cost of a spare motor may be justified. If this cannot be obtained, probably a plan can be worked out in advance whereby a motor doing less important work can be used temporarily while the more essential one is being repaired. In a direct-current machine the armature is the vital part, and if the motor is of particular importance, then a spare armature at least should be made available.

The cost of spare parts is something that is frequently looked at as running into considerable expense. This is probably true if the price paid for them is considered rather than the actual cost of making them available. An extra armature for a motor may cost one hundred dollars, but if this money can be obtained at six per cent, the cost of providing the spare part is but six dollars a year, an insignificant amount for insurance against protracted delays in operation. Where a number of similar motors are used, the cost of maintaining spare parts is reduced per motor in almost direct proportion to the number of like machines in use. A little foresight in maintaining equipment and a few dollars invested wisely, will prove to be good insurance against trouble, and when difficulties do arise, those responsible will be well prepared to meet them.

Lessons from the Twelve Hundred Degree Power Plant

ALTHOUGH a temperature of 750 degrees F. is now regarded as the maximum for central stations (the majority still operating appreciably below this figure), yet the use of steam at 1,200 degrees, as described in this issue, has been successful in torpedo service where dependability is paramount. In a way this is a toy plant which one man could easily carry, supplying only intermittent service and receiving expensive high-grade attention, but in spite of these unduly favorable conditions the fact remains that the torpedo power plant at this temperature extreme has made absolutely good, and not without sound reasons. As a lesson to stationary practice this should not be passed over lightly.

The boiler plant suggests simplicity, minimum space, direct contact of water with ignited fuel, positive draft control, and in many ways a nearer approach to the ideal. The presence of noncondensible gases makes it unsuitable to condensing practice.

An outstanding feature, apparently the most signifi-

cant, is the application of water jacketing to boiler and piping. Loss by radiation is then the compromise—an accepted condition, which is the price of thermodynamic gain. As in familiar examples of water jacketing, however, the desired result cannot well be measured in terms of efficiency. It is materialistic in character and one of the important keys to practical success. In this instance as in others, water jacketing makes it possible to handle extremes of temperature with ordinary commercial materials. It is a time-worn expedient whose possibilities may not altogether be exhausted. Strange to say, tests indicate that losses due to radiation and convection are far from prohibitive, being in fact well within conservative limits.

Unlike familiar examples of steam plants, the limitation of temperature lies in the turbine rather than the remainder of the equipment. It seems but reasonable to suppose that if materials available six or eight years ago gave satisfaction in the torpedo turbine, then it should be a comparatively simple matter, in the light of present metallurgical progress, to arrange a high-speed, small-diameter multi-stage turbine for continuous duty with 1,200-degree steam at reasonable cost. Elevating temperatures is relatively more productive of efficiency than increasing pressures. Thus, if steam at 700 degrees, 400 pounds be doubled in pressure, the gain in Rankine efficiency will about equal that from raising the temperature to 1,100 degrees which is about a thirty-five per cent increase of absolute temperature over the assumed conditions. The steam turbine of the future in all probability will be subject to radical change in spite of views sometimes expressed regarding its present high state of perfection.

Efficient Power Generation Versus Fuel Economy

CERTAIN plausible fallacies hang on in a remarkable way. The only remedy in such cases is to hammer away with the facts, even at the risk of boring those who have already learned to see things straight.

Such a fallacy—one that has gone hand in hand with honest engineering arguments in favor of "superpower"—is that the transfer of load from isolated plants to large central stations using less fuel per unit of power output will necessarily result in the conservation of fuel. *Power* has repeatedly exposed the fallacy in this "self-evident" proposition and must continue to do so as long as intelligent citizens continue to accept it without question. That this situation exists is beyond cavil. Hardly a week passes without some statesman or business man of good reputation and supposedly sound judgment repeating this argument in one form or another.

The immediate cause of this editorial is a recent book entitled "Coal Carbonization," by H. C. Porter, published under the auspices of the American Chemical Society. This book, by the way, is a fine piece of work. The author's competence and freedom from any desire to mislead the reader is evidenced throughout. The only exception here made is to a passing statement which the author doubtless took on faith from the utterances or writings of specialists in the power-plant field.

On page 37 he says: "Some of the methods of coal conservation . . . are . . . centralization of power production in large distributing stations with increased average load factors, and economy of conversion of fuel to power." Leaving the Diesel engine out of consideration, it is undoubtedly true that a modern central station can produce considerably more kilowatt-hours from a ton of coal than can the average isolated plant. In many cases this difference is sufficient, after allowing for distribution losses, to deliver more kilowatt-hours to the customer per ton of coal burned at the central station than the customer could produce himself from the same amount of coal burned on the spot.

It is not the purpose here to discuss the business problem of deciding whether to make one's own power or to purchase it. Such a problem is necessarily settled on the basis of comparative net cost to the consumer and not on considerations of national fuel conservation. Sticking to the question at hand—that of national fuel conservation—it is only necessary to point out, as has been done repeatedly before, the fact that many manufacturing plants as well as hotels, office buildings, laundries, etc., have use for large quantities of low-temperature heat in the form of exhaust steam, hot water or hot air. While an isolated plant in such a location may burn considerably more fuel to supply steam to engines or turbines that produce a given output of electrical energy, the waste energy in the exhaust steam can be largely utilized for heating and process work. The central station, on the other hand, discharges about sixty per cent of all the energy of the coal into the condenser circulating water, where it performs no more useful service than keeping the fish warm. So far as national fuel conservation is concerned, it is invariably wasteful to transfer load from isolated plants to central stations in cases where the exhaust steam can be fully utilized.

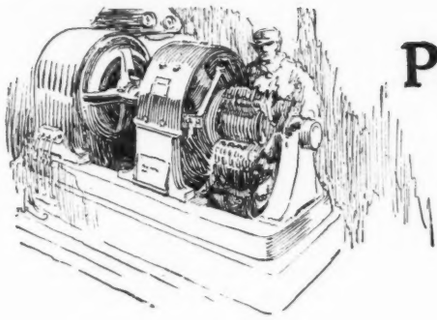
Engineer's License Laws Not Consistent

THE "Digest of Engineer's License Laws," which accompanies this issue as a supplement, shows upon analysis the wide diversity of requirements that prevail in the laws on this subject in the different states and cities.

Several of the states have laws that are uniform throughout for towns and municipalities in the state; some states permit municipalities above a given population to make ordinances covering the licensing of engineers; other states, in fact the greater number, have no laws at all on the subject.

Requirements range from five years of experience in operating plants to six months' experience for a first-class license. Fees run from nothing at all to ten dollars. Examinations are sometimes written, consisting of from a dozen to fifty questions; again, the applicant is examined orally upon his practical knowledge, and frequently, a couple of vouchers from citizens or engineers will be found sufficient to obtain the license.

While it is recognized that uniformity might be difficult to obtain, it would be entirely practical and a distinct gain to the operating engineers, were associations representing them to indorse a model law of reasonable requirements, which could be used by the state associations as an argument and an aid for persuading legislators to adopt some reasonable law. The working out of the A.S.M.E. Boiler Code is a good example.

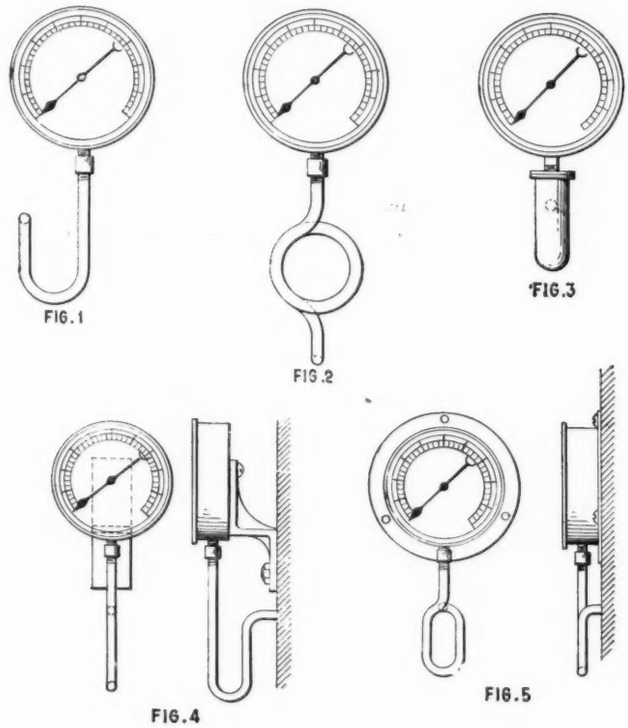


Practical Ideas *from* Practical Men

The Protection of Pressure Gages

Steam and hydraulic pressure gages should be looked upon as instruments of precision, but being made with all the working parts inclosed, they are too frequently regarded as useful attachments absolutely immune from damage or trouble.

In large steam plants of recent design the possibility of accidents or damage to steam gages is practically nil. Smaller stationary boiler installations of the older type often have a weak spot somewhere, but even in these cases the risks are comparatively small. The small portable boilers as used by contractors and others for many purposes, are the most neglected in the matter of safety; and as they are usually found to be the type of steam-raising equipment most roughly handled, it



Figs. 1 to 5—Methods of supporting and attaching pressure gages

is essential that we afford the pressure gages on such the necessary protection.

Our first consideration should be the prevention of damage to the gage of such a boiler from external causes. The weakest point is where the gage is attached to the boiler. For the present the gage itself may be considered of adequate strength, as it is unquestionably superior to the average form of attachment.

Most pressure gages are connected solely by some form of siphon to the boiler or pressure vessel, the most common types of which are shown in Figs. 1 and 2. Fig. 3 shows a more substantial type of mount-

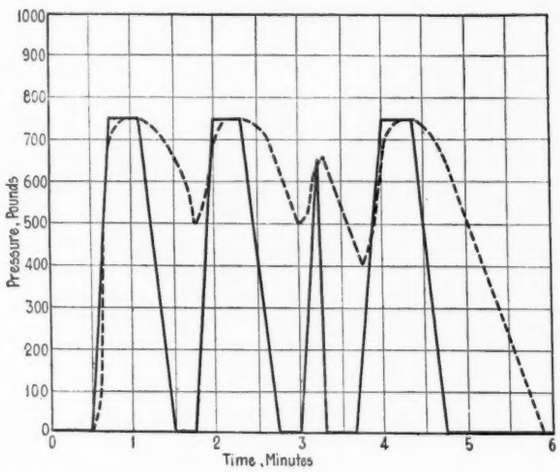


Fig. 6—Pressure diagrams obtained on testing machine

Heavy line shows actual pressure diagram on the head; light line shows pressure curve over same period with cushioning device in gage connection.

ing, but even this will not withstand any ill usage. Figs. 4 and 5 are types of connections which appeal to me on account of the rigid support given to the gage and the removal of the weight of the gage from the siphon.

Many who read this article, will probably hold the opinion that a siphon such as shown in Figs. 1 and 2 is satisfactory. I was of the same opinion until two incidents occurred that impressed me with the need of making provision against the recurrence of what in one case might have been a serious accident and prompted the suggestions contained herein.

To make a change in the form of connection does not entail much expenditure of either material or labor, since one's blacksmith can usually make a satisfactory bracket in a few minutes.

Now to consider the possibility of damage to pressure gages from internal conditions. Fortunately, provided a steam gage is connected through a siphon, it is protected from the effects of the steam itself, and unless subjected to many sudden changes in pressure, it can be expected to have a comparatively long life in service. On the other hand, hydraulic gages in use on testing machines are found to have a useful life of only a few hours in many cases.

Here one is faced with conditions that rapidly shatter the mechanism of the best gages made unless a suitable

shock-absorbing device is used in connection with it. The one important difference between hydraulic gages and gages on steam and other services is the difference between liquids and gases. Liquids are to all intents incompressible; if a pressure is exerted at any one point, it is transmitted through the liquid in all directions without any perceptible loss, while a gas is compressible, with the result that there is not the rapid shattering effect of the liquid on the gage. Fig. 6 represents the actual conditions met with on a hydraulic test bench. The solid line shows the actual pressure diagram on the head, from which it is easily understood that no pressure gage directly connected could retain its accuracy for long, even if its construction were abnormally strong. The dotted line shown on the diagram is the pressure curve over the same period, recorded on another gage connected through the device shown in Fig. 7.

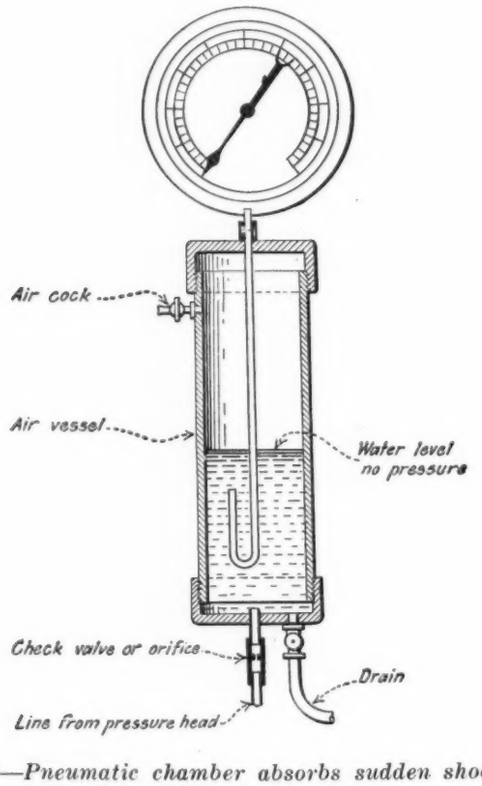


Fig. 7—Pneumatic chamber absorbs sudden shocks in hydraulic gage connection

The action of this attachment, it will be noticed, retards the sudden fall in pressure and also cushions the rising pressure when the valve is reopened. The construction of the attachment itself, as also its operation, is extremely simple, consisting as it does of an air vessel of ample proportions containing the pressure-gage siphon and connected through a check valve with a serrated seat or a small orifice to the pressure head. As previously mentioned, a pressure gage is of service only as long as it retains its accuracy, and as only simple attachments such as are described are necessary to prolong materially the useful life of many pressure gages in use, it is surely a desirable means of obtaining both a saving in money and a greater degree of safety.

G. ERNEST BOOKER.

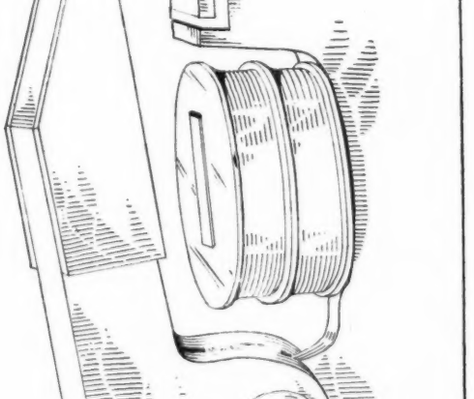
Gardenvale, Que., Canada.

Broken Shading Coil Caused A.-C. Magnet To Chatter

One of the difficulties experienced with alternating-current magnets is their tendency to chatter or hum, particularly with the single-phase type. Since the current is alternating, it increases from zero value to a maximum, decreases to zero, reverses and passes through a similar series of values in the opposite direction. The magnetic field passes through a similar series of values to the current, so that when a contactor is closed and held closed by a single-phase alternating-current coil, the pull holding the switch closed varies from zero to maximum and then back to zero. When the holding force is at a maximum, it is more than sufficient to hold the contactor closed and, when this force approaches zero, the contactor tends to open. As a result, if means are not provided to overcome this defect, the magnet will chatter.

A device that has come into common use to prevent single-phase alternating-current magnets from chattering is known as a shading coil. It consists of a copper loop around part of the pole face, as indicated at *A* in the figure. This loop has a current induced in it the same as would be in the short-circuited secondary of a transformer. The current in the shading coil is at a maximum when the current in the main coil is zero and produces sufficient flux in the magnetic circuit to hold the contactor closed while the primary magnetizing current is passing through zero.

In one case one of the magnets on the control board for automatically starting a large motor, developed a bad case of chattering. When the coil was energized, it would close the armature, but instead of holding the contactor closed, it would chatter continuously. After trying various remedies and making all possible adjustments without any improvement, a new contactor was obtained and replaced the one giving trouble.



Single-phase magnetic contactor; shading coil at A

After the old contactor was removed, it was found that the shading coil was cracked so as to break the circuit through it. When this defect was repaired, the magnet gave normal operation when tested.

Boston, Mass. B. A. BRIGGS.

Comments from Readers

Safety Valve for Closed Heaters

Referring to the inquiry of B. N. in the Aug. 5 issue on "Safety Valve for Closed Heaters," all closed heaters should be provided with relief valves whether they are subject to excessive pump pressure or not.

A number of accidents have been caused by turning steam into a cold heater with the water inlet and outlet valves closed, the expansion of the water creating a destructive pressure. Heaters piped up in parallel are especially subject to this condition. Overpressure from pumps is usually relieved by a relief valve at the pump.

Powell River, B. C., Canada. M. S. GEREND.

Quality Coals Produce Efficiency

So much has been said in the past regarding the use of certain appliances or equipment that would enable the steam-plant owner to utilize cheap coals, that many engineers and owners are apparently of the opinion that high-grade or "quality coals" would as a matter of course result in a higher steam cost than those which cost less per ton.

Many years' experience in various types of power plants and with many different kinds or grades of coals from several states, has convinced me that the old slogan, "The Best is None too Good," not only applies to the equipment and supplies used, but also should include the coal.

Many plant owners have turned to the use of fuel oil simply because they had come to the conclusion that the coal man either would not or could not deliver quality coals of specified heat value and with a minimum ash content, while they had been convinced that they could depend upon a certain number of B.t.u. if fuel oil was used.

Certain coal men have been guilty of profiteering in the marketing of coal—mostly coal brokers who did not actually produce the coal and were therefore not interested in securing permanent business. They were only interested in securing profits for the time being.

There are, however, many reputable coal operators, just as there are certain well-known reputable manufacturers of steam turbines, engines, etc., the chief difference being, perhaps, that "brand names" of coal have not been consistently advertised and kept before the coal-purchasing public; and furthermore, the coal operator or producer has not in the past employed the proper type of sales engineer to make a study of the steam users' conditions and requirements. Several large producers have done this and gone into the matter with a view of giving the steam user every possible assistance, with the result that during the last few months, when many mines were either closed down or working only one or two days a week, they have made a record in sales and production.

Many years' experience has proved conclusively to me that while attractive results are often secured with low-quality coals or byproduct fuels in tests of short duration, the chief engineer or power-plant superintendent who insists upon the purchase of coals on a sensible quality basis—coals with the proper volatile content and a minimum ash content—are most successful in the long run. In other words, many able engineers have been lost because of the purchase of inferior coals not suited to the conditions. On the other hand, also, many able engineers have lost good positions because they were too enthusiastic regarding the use of cheap fuels, and in their extraordinary efforts to prove that their hobby was correct, they neglected other details of their plant, which resulted in poor service.

I speak from experience on both sides of the fence, therefore I feel confident that most power-plant owners or steam users would secure the maximum efficiency and lowest steam cost in the long run through the use of high-quality coals best suited to the local operating conditions. WALDO WEAVER.

North Tonawanda, N. Y.

How To Avoid Clinkers with Hand-Firing

The article by C. Rye, in the Aug. 12 issue, on "How To Avoid Clinkers with Hand-Firing" was instructive, and I wish to state my experiences along the same line.

Any engineer who has fired marine boilers knows the trouble usually experienced with clinkers. I have in my boat one water-tube boiler. The fuel is mine-run soft coal containing a high percentage of dirt. I have to use a jet of steam in the stack continuously when under way, as the steam will not hold without it. The grate surface is 4 ft. long and 3 ft. wide and, as is usual in marine work, the bars are stationary.

Every Saturday night I let the fire out, and Sunday morning (as we make only one trip in the afternoon) I clean out the ashes and dirt and look over the brickwork, tubes and grates. Then, after disposing of the ashes over the side, I spread about 3 in. of clean lump coal over the grates, then add the wood, in an even layer of about 12 in. thick, on top of the coal. If the wood is very wet, I throw some kerosene on it for a starter. Then I soak a piece of dirty waste in oil and place it just inside the door and light it with a match, leaving the firedoors open until the fire gets a good start. I have been able many times to have 100 lb. pressure in forty minutes in this way with only natural draft.

Occasionally, upon opening the furnace door, the fire appears to be two feet high from the grates, and as soon as I place a shovelful of coal on it, that part at once sinks, showing that it was about hollow. I manage to leave some ashes on the grates, as that seems to prevent their burning out and warping. I find that the whole secret is to keep a level and thin fire without stirring it with the fire tools and to keep the door shut as much as possible. Also, I get good results by watching the top of the stack instead of opening the firedoor every few minutes.

At night, when ready to bank the fire, I leave it level as when under way, and at the proper time I start to

fire one side only about halfway back from the door, and I keep firing this same place till I have it about 1½ ft. thick. I find that this leaves a good fire to start with in the morning, and all I have to do is to rake out the ashes and spread the bank over the grate.

Old Forge, N. Y. R. G. SUMMERS.

The Steam Heating Business

In the Aug. 5 issue Mr. Douglas urges a more serious consideration of the opportunities offered by central steam heating. He cites Milwaukee as an example of the operation of a completely successful system. This system is profitable for the utility and economical for the customer. Not even the fussiest coal conservationist could find fault with a method that generates power wholesale and then delivers the low- or medium-pressure exhaust into heating mains for wide distribution. That is, unless he would say that it still uses raw coal instead of using coke from which the valuable byproducts had already been extracted.

I suppose it was Mr. Douglas' idea that the central steam plant should furnish power as well as heat, and I suppose that the Milwaukee plant to which he refers does this. Then isn't Milwaukee's plant rather favorably located for such an arrangement? How many large cities would find it practicable to do the same thing profitably?

Suppose the utilities of such cities as Philadelphia, Chicago, or New York would start such service or would plan to extend present plant used for that purpose. Because they must have unlimited quantities of condensing water for at least part of the year, the large generating stations are located on waterfront. Congested business districts and waterfront are seldom in the same place.

Heat losses make extremely long feeder lines questionable. That means that isolated stations for steam heating would be necessary. This in turn would mean two things—increased labor costs, with the necessity for changing the size of the force at different seasons, and usually non-condensing power units, which would be used only in the heating season and would carry heavy stand-by charges.

Both these things would increase power costs materially and decrease reliability. Enormous generating stations, such as are springing up so rapidly, are justified, and they are justified largely because they reduce the costs per unit of output, for labor and supervision, and they increase reliability.

If we increase the power costs, we throw the profit-making burden onto the heating steam. That brings the price of steam up nearer the point at which the private plant can generate it and makes the end of the rainbow seem farther away.

Further, the bulk of such heating service would have to be sold to industries and buildings now operating their own plants for heat and power. The private plant would be closed down, but the fixed charges would run right on. The customer's bill would then be made up of the following items: Fixed charges on his own idle power plant; the fixed and operating charges of the public utility for the production of heat and power; distribution costs and losses and profit. Would it not seem reasonable to expect a fairly well-operated private plant to show a better figure than this total for its own operation?

The public utilities are in business for the purpose of making money. They lose many electric accounts that would be extremely profitable because they are not able to supply heat as well as power. Why shouldn't they jump at the chance to corral this business by furnishing heat?

I do not think it is fair to assume that the electric companies have been so thoroughly swept off their feet by their zeal to build larger power stations and use higher pressures and larger generating units, that they have entirely overlooked the possibilities of central heating. I believe that many of them must have given serious thought to the matter and must have decided that the dollars-and-cents side of the story isn't always as rosy as the steam-table figures would have us imagine. W. J. RISLEY, JR.

Philadelphia, Pa.

[The subject is one that will bear careful analysis, especially in view of higher steam pressures and the economies of bleeding steam. Further discussion is invited.—Editor.]

Mechanical Forces in Power Transformers

In the July 29 number of *Power* there appears an article on "Mechanical Forces in Power Transformers." This article is not specific in its use of fundamentals as applied to actual machines, resulting in unfair conclusions on the proper design of power transformers.

The author states: "If a square coil, as shown in Fig. 9, is used, the mechanical forces set up inside the coil due to the repulsion of lines of force will tend to make it take a cylindrical shape." Referring to his Fig. 1, which shows primary and secondary coils side by side on a core, he quite correctly shows no radial forces. There being no radial forces for such an arrangement of coils, why would not a rectangular coil retain its shape?

An inconsistency of the discussion appears in connection with his reference to Fig. 11. He states: "When the coils have an iron core, the lines of force concentrate in the core and exert a force which tends to pull the inside coil toward the core." Yet the relative direction of flux and current in this inner coil as shown in the sketch is the same as for the individual coils analyzed, where he concludes that the forces tend to move the coil outward (increase its diameter).

The most outstanding fallacy appears in the next to the last paragraph, with reference to the design of coils. The article reads: "The forces within the coils themselves have been successfully taken care of by shaping the coils so as to equalize them over their entire circumference. This is possible only with coils of circular form. A coil of any other but circular form will tend to become circular under stress of a short-circuit, as explained in the foregoing." A careful consideration of the subject and also the only correct conclusions that could be drawn from the author's fundamental considerations show that his statements apply only to windings where the primaries and secondaries are concentric. There are many large power transformers now in operation having rectangular coils, the primary and secondary windings of which are not concentric, and their ability to withstand mechanical stresses incident to short-circuits is unsurpassed by any other existing form of construction.

J. F. PETERS, Technical Assistant,
Westinghouse Electric & Mfg. Co.
East Pittsburgh, Pa.

Burning Anthracite in a Modern Steam Plant

The article by E. E. Rowe in *Power*, Aug. 19, proves conclusively that a stoker, equipped with a properly designed furnace and properly operated, will yield an efficiency comparing very favorably with and an economy probably exceeding that of the newer methods about which much has been written of late.

The curves in Fig. 2 of that article (herewith reproduced), while showing excellent performance, are not beyond the comprehension of those familiar with stoker operation in well-designed and efficiently operated steam plants, except for the top curve showing "Per Cent Combustile in Ashpit." These results are so different from those obtained in some efficient plants with which I have had the good fortune of being connected that I believe Mr. Rowe would render a real service to the stoker-operating fraternity by explaining how such results may be obtained.

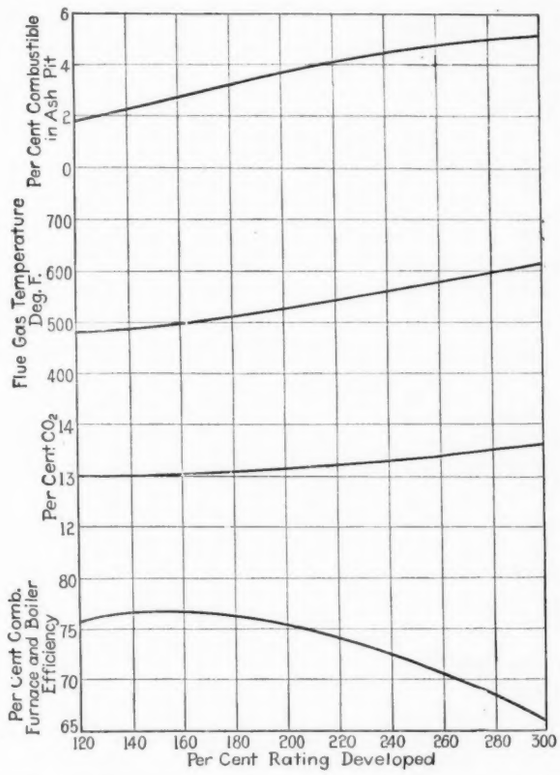
About five years ago I conducted a series of exhaustive tests for an industrial concern operating two boiler houses. The main boiler room was equipped with 4,400-sq.ft. water-tube boilers and traveling grates and was operated at about 200 per cent of rating; the auxiliary boiler room was equipped with 2,500-sq.ft. water-tube boilers with pin-hole grates and was operated at about normal rating. The results of those tests indicate that with No. 3 anthracite buckwheat containing about 17 per cent ash, the refuse from the stoker boilers ran 26 per cent, from the hand-fired boilers operated by one man 19.5 per cent and from the hand-fired boilers operated by another man 21 per cent combustible. Samples taken of the refuse, quenched immediately upon removal from the asphalt and furnace, were analyzed and the results indicated that the combustible in the refuse from the stoker boilers was about 35 per cent, from the hand-fired boilers operated by one man 13 per cent, and from the hand-fired boilers operated by another man 19 per cent. These results came as a thunderbolt, for everybody interested in the tests was sure that the percentage of combustible in the refuse ought to be higher for hand-operated boilers.

Numerous subsequent tests confirmed these results. They also showed that the only way to reduce the combustible in the refuse is to reduce the speed of the grates and decrease the thickness of the fuel bed, which would result in a decreased steaming capacity of the boilers. As the forcing of the boilers resulted in a high flue temperature and loss as well as an abnormally high superheat, serious operating difficulties, including damage to the turbine, were encountered. Additional boilers were installed and the entire boiler room operated at 100 to 120 per cent of normal rating. The combustible in the refuse was reduced to about 22 per cent and the over-all economy of the boiler room remarkably increased.

In the fall of 1923 the question of "what is a reasonable per cent combustible in the refuse, in traveling grate operation" came up in connection with a steam plant consuming about 200 tons of coal a day. Samples of the ash were taken daily, collected for a week and then analyzed; the results showed a variation between 24 and 30 per cent. The management thought it "awful," but I claimed that it was "not bad."

I decided to obtain data to substantiate my claims and eventually received five letters from stoker manufacturers. Three of the letters discussed the subject in a general way, but gave no definite figures; one letter gave a table showing an increase from 8 to 14 per cent combustible in the refuse with the increase from 100 to 250 per cent rating, but it impressed me that the figures were hypothetical rather than based on records of actual performance. The fifth letter, from a manufacturer of an underfeed stoker, contained an interesting discussion of the subject, explaining that the stoker itself would do no better than 15 per cent combustible in the refuse and that by means of an attachment his company had developed, this could be considerably improved upon, and that the saving effected would pay for the attachment in a very short time.

In seeking further light on the subject, I discussed



Results obtained by E. E. Rowe with No. 3 buckwheat on stokered boiler

the matter with a combustion engineer of a large public utility corporation. He informed me that 17 per cent combustible in the ash is considered good operation in their plants.

I believe that stoker operators would appreciate authentic information which they could use as a standard of comparison for their own performance. With a statement to the effect that "in average stoker practice 35 per cent combustible in the ash is frequently met with," on page 288 of *Power* and a curve on page 292 showing the same item to vary between 1.9 and 5.1 per cent, the operator getting, say, 20 per cent combustible in the refuse of his boilers, is wondering whether he is doing better than the average or ought to be ashamed of the poor showing he is making.

E. OGUR.

New York City.

[The title of the top curve in Fig. 2 should be "Per Cent Loss in Ash Pit" instead of "Per Cent Combustible in Ash Pit." This error was not detected at the time it was received.—Editor.]

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Position for Eccentric When There Is a Double Rocker

When the valve rod of a slide-valve engine is operated from the eccentric rod through a double rocker that causes the D slide valve to be moved in direction opposite to the direction of motion of the eccentric rod, where should the eccentric be located on the shaft to obtain proper movement of the valve? M. W.

When there is a double rocker, the center of the eccentric must be set about 90 deg. behind the crank, or as much in advance of that position as may be necessary to give the proper admission and point of cutoff.

Operating Induction Motor with Rotor Connected to the Line

We burned out the rotor on a 20-hp. alternating-current slip-ring motor and found that the current was hooked up to the rotor instead of the stator. If this is wrong, how can a motor run two years without giving any trouble, and will it take more power to operate a motor in this condition? A. A. B.

This is possible where the design is suitable to operate an induction motor inverted, with normal results in all particulars. The first line of polyphase induction motors that were built by the Westinghouse company operated in this manner. They were known as type B induction motors, but were later superseded by the type C and the line connections changed from the rotor to the stator. If there are the proper number of turns in the rotor winding for generating the counter-electromotive force for the given conditions, there will be no difference whatever in the operation of the motor from that experienced under what are now regarded as normal conditions. It would of course be necessary either to put a squirrel-cage winding on the stator or, if coil-wound, to handle it with starting resistance and short-circuiting device, just as is now done in the standard phase-wound motor.

Laying up Steam Turbines

We have two impulse turbines which may be operated condensing or non-condensing. Having arranged to operate our plant by electric power received from a public central station, what should be done in laying up the turbines to stand by in good condition, ready to start when needed? R. E. R.

When the turbines are shut down and drained, pour about one-half gallon of engine oil in the cylinder of each turbine when slowly turning over, and work the oil through the cylinder to coat thoroughly the blading, packing glands and other finished parts. Care should be taken that the turbines are completely disconnected from any live or exhaust steam. To guard against rust or damage from such connections, close the throttle valves and provide bleeders outside of the valves with independent openings to the atmosphere. Any drains connected with other drips should be disconnected close to the machines, and the drain pipes should be blanked off to prevent steam from backing up to the turbines. After the turbines are thoroughly drained, close the exhaust valves and open a bleeder outside of the exhaust valves to prevent any steam backing up from other connections. After all finished parts have received a doping of thick oil, provide the turbines with tarpaulins or canvas coverings for protecting them from dust.

Noise and Breakage of Diesel-Engine Piston Rings

We have a two-cylinder 100-hp. two-stroke-cycle semi-Diesel operating at 257 r.p.m. The rings on the pistons of this engine have persisted in "snapping" even immediately after rings and pistons have been cleaned. No lubrication difficulties have been encountered, and almost no ring sticking has been experienced. The engine has been operated approximately 4,000 hours. No breakage of the rings has occurred except at the ends where they are pinned to prevent turning on the piston. The snapping noise seems to occur from the same cause that breaks the ends of the rings, and there is no evidence of excessive wear either on the ring seats or cylinder walls. Can you suggest the cause and remedy for the trouble? G. E. Z.

This snapping is caused by a too light fit of the rings in the grooves. The piston, in moving down on the power stroke, is thrust against one side of the cylinder; the rings are then pushed back so that they are flush on this side of the piston and protrude on the other. On the upstroke the tight rings remain in the same position, holding the piston against the cylinder wall. Upon the injection and firing of the charge, which takes place before top dead center, the cylinder pressure throws the piston against the cylinder wall opposite to where it is bearing; the rings are then forced back into the groove with a sharp snap. By filing the edges of the rings to give more clearance, the trouble should disappear.

Exhaust Pipe Sizes

What sizes of exhaust pipes should be provided for engines of 150, 500 and 650 kw. capacity, and what should be the size of a common exhaust main from the three engines? P. F. R.

The size of exhaust pipes for each engine should be the full size of the exhaust connection provided by the builder of the engine. When the sizes must be decided

upon in advance of this information, the exhaust branches should be at least 7 in. for an engine of 150 kw. capacity, 12 in. for 500 kw. and 13 in. for 650 kw. capacity. Ordinarily, the sizes provided in the engine connections may be continued for the full lengths of the pipes without material increase of the back pressure. Where two or more engines exhaust into a common main, it is the usual practice to provide a main whose cross-sectional area is equal to the combined areas of the branches. This, however, results in greater carrying capacity or less back pressure than if the mains were carried side by side for the same distance, since the capacities of pipes of the same length and the same drop in pressure are as the square roots of the fifth power of their diameters. Hence for the same back pressure from a single main as from branches respectively 7, 12 and 13 in. in diameter and for the same length, the main could be about 16 in. in diameter.

Balanced Draft

What is meant by operation of a boiler with balanced draft? *B. D. A.*

The term balanced draft is generally applied when the draft pressure above the fire, resulting from a forced-draft air supply is equal or very slightly in excess of the pressure of the atmosphere. When this draft condition exists, heated gases of the furnace are not lost by being forced out through the firedoor or crevices in the boiler setting; and as with balanced draft in the furnace the required force of draft in the boiler uptake is no more than necessary for overcoming the draft losses between the furnace and stack damper, infiltration of air through openings or crevices in the boiler setting, with resulting loss of economy, is reduced to a minimum.

Grooving of Boilers

What is grooving of a boiler and what parts are most affected by this kind of corrosion? L. D.

Grooving of a boiler is deep corrosion which takes place in parts of the boiler material that are subjected to slight bending, due to changes of pressure and temperature. Slight movements, often repeated, loosen particles of rust as fast as they are formed, thus exposing a fresh surface for the formation of rust.

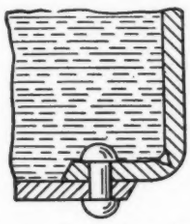


Fig. 1—Grooving in corner of boiler head

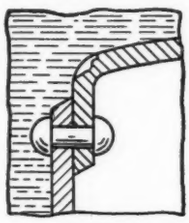


Fig. 2—Grooving at corner of crown sheet

When the corrosion thus induced is confined to a particular place instead of being spread over an extensive area, it produces grooving. The action is most likely to occur at corners in such locations as where the head of a boiler joins the shell. In such cases it is due to movement of the head with respect to the shell. An example of this kind of grooving is shown in Fig. 1. Such grooving may be avoided by bracing the head to prevent hinging movement of the flange.

Sometimes grooving is found at the rounded corners of locomotive type boilers where the furnace crown sheet is flanged to meet the furnace side sheets, as shown in Fig. 2. In some cases grooving is found at the bottom of the water leg in locomotive types of boilers, and also in the water leg of vertical boilers, especially when the water leg is fitted with a solid mud ring, as shown in Fig. 3. Grooving, as shown in

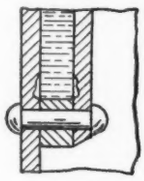


Fig. 3—Grooving in sheets of water leg

Fig. 4—Grooving along longitudinal lap joint

Fig. 4, often occurs along the longitudinal seams of boiler that have lap joints which run the full length of the boiler. This is of more frequent occurrence in boilers of small diameter such as vertical boilers, and is due to the bending action that occurs in a lap seam when the boiler is subjected to changes of pressure. Such grooves do not occur where butt and double-trap joints are used for the longitudinal seams.

Cause of Generators Not Operating in Parallel

Can you suggest what the trouble is with two direct-current generators that will not operate in parallel? The generators are driven by 550-volt synchronous motors. No. 1 generator is rated at 100 kw., 1,200 r.p.m., 250 volts and No. 2 at 100 kw., 900 r.p.m., 275 volts. The load supplied fluctuates through wide ranges. No. 1 generator holds its voltage nearly constant when load is applied, where the voltage on No. 2 decreases under the same conditions.. On a steady load and the machines operating in parallel No. 1 gradually picks up the load while No. 2 rejects its load. *J. W. B.*

There may be other conditions that have an influence on the problem, but the first thing to do is to get both machines so they have nearly the same voltage characteristics. Until this is done, there is no use trying to get them to operate in parallel. Apparently No. 1 machine is flat compounded while No. 2 has a drooping characteristic. It may be that the series- and shunt-field coils of No. 2 machine have opposite polarity, or some of the series coils have wrong polarity. If these conditions do not exist, change the resistance of the compounding shunt on the series field coils to give the machine the correct compounding. By decreasing the cross-section—that is, increasing the resistance—of the compounding shunt, more current will flow through the series-field coils and the higher the voltage under load. It may be that removing the shunt entirely will not give sufficient compounding, in which case it will be necessary to reduce the resistance of the compounding shunt on No. 1 machine so that its compounding characteristics will be the same as those of No. 2 machine with the shunt removed. After this has been done and the machines are connected correctly for parallel operation, no trouble should be experienced in getting the machines to operate in parallel and divide the load between them.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor]

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

Picturing Combustion

MOST practical minds work best by picturing things in three dimensions. This method of attack is particularly valuable in studying the chemistry of combustion, as the present article will attempt to demonstrate. It should be stated at the outset that the atoms and molecules do not look like the sketches here shown. It is hardly necessary to say that a molecule of gas is not a hollow cubical box containing in its center two or more atoms.

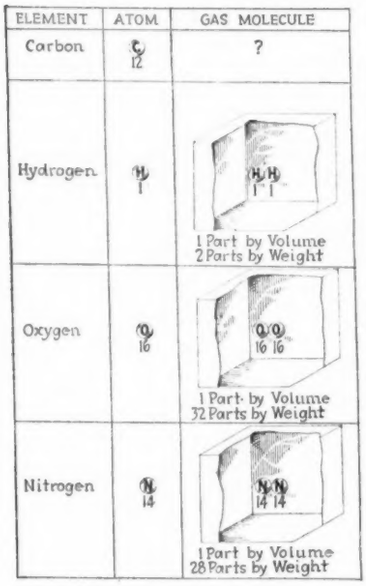


Fig. 1—The elements

Yet this simple method of representing the atoms and the molecules gives a picture which, from the practical point of view at least, is satisfactory for ordinary combustion problems. In such problems it is sometimes more convenient to work by volumes and sometimes by weights. Either method is equally easy if the fundamental principles are understood.

TABLE I.—PRINCIPAL ELEMENTS FOUND IN COMBUSTION PROBLEMS

Element	Chemical Symbol	Atomic Weight
Carbon	C	12
Hydrogen	H	1
Oxygen	O	16
Nitrogen	N	14

Table I lists the principal elements found in combustion problems. The atomic weights given in the third column are merely the relative weights. Hydrogen being the lightest element, its weight is arbitrarily taken as 1. The atom of oxygen is known to weigh sixteen times as much as that of hydrogen. Hence its atomic weight is 16, and so on for all of the elements.

Table II lists the molecules encountered in combustion problems, the molecule being the smallest division of the material that can conceivably be made without destroying the substance.

TABLE II.—MOLECULES ENCOUNTERED IN COMBUSTION PROBLEMS

Name of Substance	Chemical Formula	Molecular Weight
Carbon dioxide	CO_2	44
Carbon monoxide	CO	28
Water	H_2O	18
Hydrogen gas	H_2	2
Oxygen gas	O_2	32
Nitrogen gas	N_2	28

The molecular weights given are obtained by adding up the weights of the atoms in the molecule. For example, the molecule of CO_2 contains one atom of carbon weighing 12, and two of oxygen weighing 16 each, giving a total of 44. It will be noted that where the elements hydrogen, nitrogen and oxygen exist in the form of gases, the molecule contains two atoms, so that the molecular weight is in each case double the atomic weight. Thus H may represent the *element* hydrogen, but the only correct symbol for the molecule of hydrogen *gas* is H_2. This might seem to be an unimportant matter, and in fact it makes no difference which is used in problems involving weights only. Where volumes are considered, it is a great help to write the formula for the molecule in the correct form, as will be shown presently.

The formula for the molecule of carbon is not given and need not be known. For practical combustion work it makes no difference how many atoms of carbon are in the carbon molecule.

When dealing with gases, it is convenient to consider each molecule as occupying a certain volume. With a fixed temperature and pressure this volume is the same for all gases, a fact that is extremely useful. Then the various substances can be represented as shown in Fig 1.

Take carbon for instance. Its atom may be represented by the small sphere with the letter C written on it. The number 12 written under the carbon atom shows its atomic weight. Since carbon is not encountered as a gas, its gas molecule is not shown.

Next comes the hydrogen. This is represented by a similar sphere marked H, and with the number 1 below it, indicating the atomic weight. As a gas the hydrogen would not exist as a bunch of separate atoms, but the atoms would join together in pairs, as shown in the figure. Now, as has already been stated, a gas molecule occupies a certain volume at a given temperature and pressure, and this volume is the same for all gases. While it *occupies* this space it does not *fill* it, any more than a man fills the house he occupies. The volume of a molecule is represented by the cube. Cubes of the same size will be drawn for all the molecules.

We then have, for practical purposes, a good picture of a molecule of hydrogen gas. Looking at the picture, we see that it consists of two atoms, that the molecular weight must be 2, and that it occupies one standard volume. It may be referred to as being one part by volume and two parts by weight.

The next line gives a similar picture for oxygen. Each oxygen atom weighs 16, and the gas molecule represents one part by volume and 32 parts by weight. The nitrogen atom weighs 14, the molecule representing one part by volume and 28 parts by weight.

This completes all the elements of any importance in combustion work. Sulphur is relatively unimportant and has been omitted.

Taking next the compound substances, it is necessary to deal with carbon dioxide, carbon monoxide, and water vapor. It will be remembered that carbon dioxide is the product of the complete combustion of carbon, while carbon monoxide represents partly burned carbon that can take on more oxygen. This becomes clear from the picture in Fig. 2. The carbon-dioxide molecule shown contains one atom of carbon and two of oxygen. This molecule represents one part by volume and 44 parts by weight. The carbon-monoxide molecule is exactly the same as the carbon-dioxide molecule in every respect, except that one of the oxygen atoms is omitted. If the conditions ar right this molecule

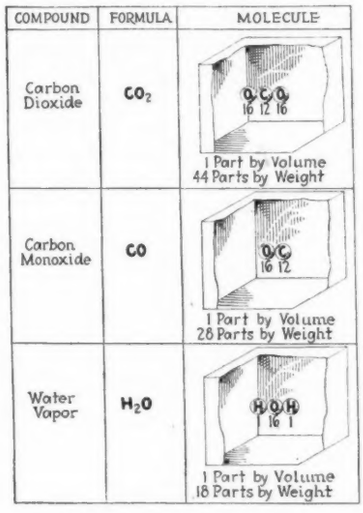


Fig. 2—The compounds

will pick up another atom of oxygen to form carbon dioxide. The molecule of CO represents one part by volume and 28 parts by weight.

The volumes shown apply only in the case of true gases. Water vapor is not a true gas, and hence the use of the same size cube for the molecule of water vapor is not strictly correct.

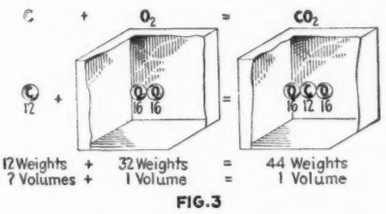


Fig. 3—Complete combustion of carbon

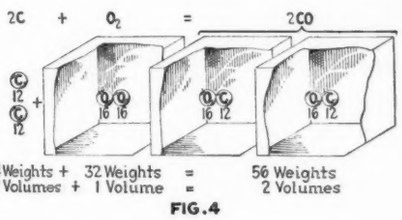


Fig. 4—Incomplete combustion of carbon

However, the volume of water vapor is of little importance in most combustion problems, as it condenses out when the analysis is made. One atom of oxygen, weighing 16, joins with two of hydrogen, weighing 1 each. Therefore, the water-vapor molecule represents one part by volume (assuming the vapor to be a perfect gas) and 18 parts by weight.

Now that the reader has in mind a clear picture of all the atoms and all the molecules concerned, it will not be difficult to extend this method to the chemical equations or reactions themselves.

Take the complete combustion of carbon shown in Fig 3. The chemist might write this $C + O_2 = CO_2$, as in the top line, by which he means that one atom of carbon unites with one molecule (two atoms) of oxygen to form one molecule of CO_2. Right below these symbols are drawn the pictures, exactly the same as those already given for the corresponding substances. These will show at once why one volume of oxygen does not make more than one volume of carbon dioxide. The carbon atom joins with the two oxygen atoms, to form a single molecule. The new molecule weighs more than the oxygen molecule, 44 instead of 32, but being still one molecule, the volume occupied as represented by the hollow cube, remains the same as before.

To obtain the third line, giving the proportions by weight, it is merely necessary to total the weights of the various atoms shown in the picture above. Thus it appears that 12 weights of carbon, plus 32 weights of oxygen give 44 weights of carbon dioxide. The last line gives parts by volume.

The volume occupied by the carbon atom, is insignificant in comparison with that taken up by gas molecules. Moreover, it is of no importance in most combustion problems. This volume is represented by a question mark. Therefore, in terms of volume, an unknown small volume of carbon, plus one volume of oxygen, is equal to one volume of carbon dioxide.

When, therefore, the carbon is completely burned with oxygen, the volume of carbon dioxide produced is equal to the amount of oxygen consumed. If, on the other hand, the carbon is only partly burned, as is the case when it combines with oxygen to form carbon monoxide, the volume of carbon monoxide produced is twice that of the oxygen consumed.

This is readily seen from Fig. 4. The first line gives the chemist's equation. In equations of this sort it should be noted that everything on the two sides balance. There are two atoms of carbon on each side of the equality sign and two atoms of oxygen. This is necessarily true, since the atoms are never destroyed, but only shifted from one position to another. The second line shows the same thing graphically. At the left are the two atoms of carbon. To this is added one molecule of oxygen. The product is the two molecules of carbon monoxide. Adding up the weights it will be seen that 24 weights of carbon, plus 32 of oxygen, equal 56 of carbon monoxide. By volume, an unknown small volume of carbon, plus one volume of oxygen, produces two volumes of carbon monoxide.

While the same atoms appear on both sides of the equality sign, it might appear that the production of two

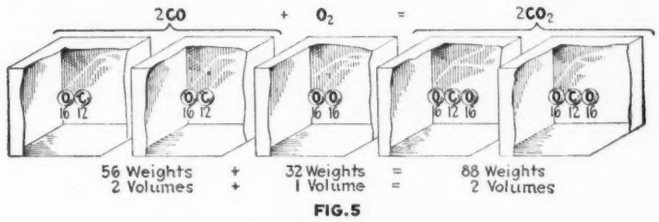


Fig. 5—Burning carbon monoxide

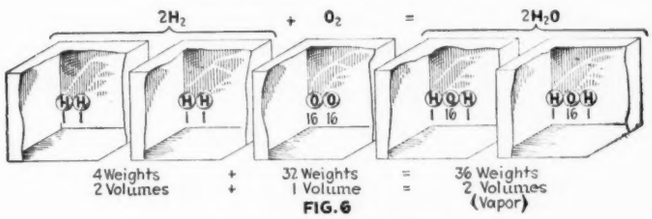


Fig. 6—Burning hydrogen

"cubes" from one is making something from nothing. The cubes, however, represent nothing but space occupied.

By mixing with more oxygen and raising the mixture to the ignition temperature, the carbon monoxide can be burned to carbon dioxide in the manner shown by Fig. 5.

In the same way Fig. 6 shows the combustion of hydrogen gas to form water (H_2O). While the weight relation holds exactly here, that for volume is only approximate in the case of the water vapor, as water vapor is not a true gas. If the vapor condenses, it does not hold at all, the volume of the liquid water being practically zero in comparison with that of the hydrogen and oxygen which produce it.

Having in this way obtained a mental picture of the combustion reactions one of the applications should be of interest.

Draw a sample of air into an Orsat and analyze it for oxygen. It will show 20.7 per cent (by volume). The remaining 79.3 per cent is inert gas, chiefly nitrogen. Next take a sample of flue gas from a boiler burning coal. Whether the CO_2 is high or low, it will be found that the CO_2 and O_2 add up to a figure somewhat less than 20.7, usually between 18 and 20.

The reason for this can be made clear with the aid of the pictures already given. Coal consists chiefly of carbon. The ash naturally has no effect on the flue-gas composition, while the moisture in the coal condenses in the sampling device or the Orsat, and hence does not appear in the analysis. The only other element of importance is hydrogen. The amount of free hydrogen in coal is relatively small. If it were entirely absent the CO_2 and O_2 of the flue gas would add up to make exactly 20.7 per cent.

That this must be true, is easily demonstrated. Picture 100 parts (by volume) of air containing 20.7 parts of oxygen and 79.3 parts of nitrogen, entering a furnace fired with pure carbon. Suppose 12 parts of oxygen combine with carbon. This leaves 8.7 parts of oxygen and 79.3 parts of nitrogen in the flue gas. Referring to Fig. 3, it is evident that 12 parts of CO_2 will be produced. The hundred parts of air will then become 100 parts of flue gas, and the percentages of CO_2 and O_2 will be 12 and 8.7 respectively, totaling 20.7 per cent the same as the oxygen originally in the air.

If, in the case just considered, one part of oxygen had burned with hydrogen and 11 parts with carbon, the flue gas would contain 11 parts of CO_2, 8.7 parts of oxygen and 79.3 parts of nitrogen, a total of 99 parts. The corresponding percentages would be: CO_2, 11.1, O_2, 8.8. and N_2, 80.1. Here the CO_2 and O_2 add up to 19.9 per cent. Fuel oil, with its higher hydrogen, would give a still lower total.

German Practice in Exhaust-Steam Engineering*

By H. Treitel

REDUCING steam pressure by throttling is a waste, because the opportunity of producing power is missed. The aim of exhaust-steam engineering is to convert into useful work the whole available temperature drop. The lower limit is fixed, but there is considerable room for raising the upper limit. It will be shown in the following by what means and to what extent mechanical engineering and German industry in general have been able to profit by these considerations.

Practice in Sugar Refineries

In the simplest case, where the steam demand normally exceeds the corresponding power demand, the back-pressure turbine or engine is utilized to advantage. One of the chief fields is sugar refineries, where the present tendency is to use a single back-pressure machine for the whole plant. The pressures on these units are gradually being raised. At the same time vacuum stages in evaporators are being done away with. Similar conditions prevail in other industries, such as dye works.

Next come bleeding machines. Of all the steam turbines under 12,000 kw. supplied during the last five years by the largest manufacturers in Germany, no less than 43 per cent were for the use or delivery of low-pressure steam. Because of the varying distribution of load, such turbines must be carefully designed. Many processes require a fixed pressure at the bleeding point. This can be accomplished by a governor which controls the steam inlet of both high-pressure and low-pressure parts simultaneously. Bleeding and back-pressure turbines are now equal to reciprocating engines, which were formerly considered superior. There are several works, chiefly in the chemical industry, using bleeding turbines as large as 6,000-kw. and delivering 43 tons of steam per hour at pressures ranging from 65 to 90 lb. per square inch.

Process Steam at Two Pressures

Bleeding turbines exhausting to process are frequently installed to give steam at two different pressures, but where the power load does not correspond with the heating load such processes may be better handled in certain cases by condensing turbines with two bleeding points. Multiple-cylinder machines have been developed for this purpose. When the first bleeding point is at relatively high pressure (around 100 lb.) the boiler pressure should be high enough to make the conversion of energy in the high-pressure stage worth while. Some pulp mills use a bleeding turbine and a back-pressure turbine on the same shaft. Both turbines are fed with live steam from the boilers and are governed in such a manner that the pressure at the two points from which the supply of steam is taken remains constant when the load fluctuates.

In another instance (a paper mill) a bleeder-type back-pressure turbine is coupled to a condensing turbine. In this set the condensing part can be disconnected when desired, thus avoiding the no-load losses for this part of the plant. If the demand for heat is small compared with that for power, large condensing turbines are installed and in addition a reducing turbine, of one of the types referred to, which is regulated to deliver steam at a constant back pressure. The energy it supplies varies according to the demand for steam.

In industries requiring hot water, such as chemical works, wool washing and other cleaning processes, the ordinary condensing plant is used for heating water, its circulation being choked either by hand or automatically. Storage tanks equalize supply and demand. Storage takes place periodically, during which times the plant will run with an artifically reduced vacuum, but otherwise with a maximum vacuum.

For using the lower ranges of pressure low-pressure and mixed-pressure turbines are used as in other countries.

Looking at the country as a whole, centralization and decentralization of power are going on at the same time. On the one hand the large central-station companies are absorbing many of the small independent power stations; on the other, numerous industrial concerns find that by combining the production of power and heat, they can produce their own electricity more cheaply than they can buy it. In non-condensing plants this is generally the case when the power load exceeds 50 hp. In the case of bleeding turbines the minimum power load that can be produced profitably is about 300 hp. This method of operation is very desirable from the point of view of national economy. On the other hand, wherever there are industries that do not require exhaust steam, it is equally justifiable for them to shut down their own power plants. The consequence of this development is that as far as the market in Germany is concerned, turbines for industrial purposes are only in exceptional cases of the ordinary condensing type.

Much consideration is being given to the connecting together of available power stations, such as those of the lignite mines. The short-circuits experienced in small plants are localized by a selective protective system. The government has co-operated in obtaining rights of way across private property for steam pipes or electric lines where these were necessary for national economy.

Attention is also being given to the interchange of energy between private plants and central stations. There is some opposition from the central stations, but such a development seems to be for the public interest. One public official in South Germany allowed private industrial concerns one kilogram (2.2 lb) of good coal for each kilowatt hour turned into the public main. This was during a period of coal shortage. While induction generators that can be switched in like motors have been considered as a means of facilitating the linking up of the large number of small works for the supply of surplus energy, the bad effect of these upon the power factor has led to general preference for the synchronous generators. When the demand for exhaust steam is small, these sets feed a wattless current into the network. This is paid for according to a special schedule. The number of installations supplying public heat is still very small.

The avoidance of exhaust losses by the use of back-pressure or bleeding machines goes hand in hand with higher steam pressures. Today the upper limit of pressure for standard boilers is about 500 lb. A pulp mill is being rearranged for a single back-pressure machine taking steam at 450 lb. and exhausting at 115 lb. to a digester, the fluctuating demand of which is equalized by a Ruths' accumulator. It is a remarkable fact that for this plant the cost of power is no greater than are the production costs for the same amount of water power. Another possibility of improvement is found in lowering the back pressure, but here the prejudice of the manufacturing foremen must, in many cases, be overcome.

Recovery of Power from Drying Process

One of the largest heat-consuming industries in Germany is that of lignite briquet manufacture. Experiments have been begun recently on a large scale to obtain not only the energy from the steam before it is used for drying, but further to utilize the heat contained in the evaporated moisture for power production. The vapor leaving the driers is cooled somewhat to eliminate dust and air, and is then used to evaporate pure steam suitable for use in low-pressure turbines. An intermediate part of the energy head is employed for manufacturing processes.

As a means of equalizing inequalities between the power and heating loads lasting an hour or more, the Ruths' accumulator has excited much interest and has been installed in many places.

The men behind these developments in Germany have been mainly the large electrical and mechanical manufacturers. The purchasers have largely left it to the manufacturers to study their problems and recommend the proper apparatus.

With the time for turning on the heat only a couple of months away. Preparedness should be the slogan of the engineer in charge of the heating system. Radiator valves and traps can be reground and packed and the return pump overhauled as easily during the next few weeks as during the first cold spell.

*Digest of paper presented at the World Power Conference.

Recent Publications

Electrical Machinery and Control Diagrams. By Terrell Croft. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City. 1924. Cloth; 5½x8 in.; 570 illustrations. Price, $3.

In this book are included approximately 500 circuit diagrams for electrical power machinery and control apparatus. No attempt has been made to include diagrams of railway, lighting, telephone and telegraph circuits. The diagrams cover circuits for the connections of simple motors with manual control to those required for large power systems.

The work is divided into nine divisions: Alternating-current generators; direct-current generators; transformers; synchronous converters; motor generators; alternating-current motors and control apparatus; direct-current motor and control apparatus; instruments; and miscellaneous, which includes circuit-breaker alarms, lightning arresters, trip coils, circuit breakers and voltage regulators. Diagrams of both old and new apparatus are given. Only such supplementary text is given as is necessary to explain the diagrams and make the use of the equipment clear. The book is intended for the practical electrical man who has to deal with industrial power circuits, and with this class of reader it should find a wide field of usefulness.

Coal Carbonization. By Horace C. Porter, chemical engineer, Philadelphia, Pa. Published (1924) by the Chemical Catalog Co., Inc., 19 E. 24th St., New York City, as one of the American Chemical Society's monograph series. Cloth, 6x9 in.; 442 pages, 61 tables and 175 figures. Price, $6 net.

This book can be recommended to those who wish to get at the facts in regard to coal carbonization on both the economic and technical sides. While written as part of a chemical series, the treatment is practical throughout.

Great credit must be given the author for keeping the book strictly free from anything in the nature of propaganda (at least conscious propaganda). He does not start out by saying that coal carbonization should be applied everywhere and will cure all the economic ills of the age. He even expresses considerable pessimism as to its early successful application in certain fields. He realizes fully that however desirable it might be from the point of view of conservation of resources to stop the burning of all raw fuel, business men cannot be expected to recommend any particular process of carbonization except in places where the markets for the products will yield them a good return on the investment.

The volume is divided into fifteen chapters dealing with the following subjects: Introduction, Fuels and Power, Industrial Systems of Coal Carbonization, The Gas Industry, Nature of Coal Carbonization, Nitrogen and Sulphur Compounds in Coal and Their Behavior in Carbonization, Primitive Carbonization Methods, the Beehive Oven, Byproduct Coking, The Working of the Plant, Various Types of Byproduct Coke Ovens, The Heating of Byproduct Coke Ovens, The Recovery of Byproducts in Coal Carbonization, the Processes of Gas Manufacture by Coal Carbonization, Low-temperature Carbonization Process, Miscellaneous Projects in Coal Carbonization, The Application of the Products of Coal Carbonization.

Much of the book, therefore, has no direct application to power-plant work, yet it will be of value to many aside from those in direct charge of carbonization processes. Those engineers (and their number is increasing) who have to deal with political and industrial problems in a broad way, cannot confine their study of fuel to the immediate power-plant applications. The study of the fuel problem is like that of a transportation network, no portion of which can be thoroughly understood without a fair picture of the system as a whole. For example, the feasibility of combining low-temperature carbonization with power generation cannot be determined without a knowledge of the present and future markets for the byproducts.

The author points out that a larger proportion of the *energy* in the fuel can usually be obtained by burning it raw in efficiently operated boilers than by first using the carbonization process to separate the various constituents. On the other hand, carbonization, while reducing the total energy available per ton of coal, puts certain portions of this energy in highly convenient and valuable form. In addition, there are such byproducts as ammonia and fertilizer, whose value does not consist in heat energy.

There are various methods of carbonization. First comes the old-fashioned and wasteful beehive coke oven in which everything is wasted but the coke. This is being rapidly replaced by the modern byproduct coke oven which yields large quantities of gas and other byproducts in addition to the coke.

As to the low-temperature processes the author is extremely conservative. While foreseeing future developments along this line, he does not anticipate the immediate general adoption of this method of handling fuel. A wide difference of opinion exists on this point.

The author's comments on the gas industry are of interest. He feels that by putting both the manufacturing processes and the rate making of the gas industry on a more scientific basis, it should be possible to make better prices to large users of gas, thus encouraging the use of gas for such purposes as house heating and industrial furnaces. At the present time the heating of entire houses by city gas is almost prohibitively expensive.

It was stated at the start that this book is unusually free from conscious propaganda. Unconscious propaganda can be found in a statement on page 37, amplified elsewhere, to the effect that centralization of power production in large distributing stations will result in the conservation of fuel. This statement is in decided need of qualification, but the author, as a chemical engineer, can hardly be blamed for making it when similar statements have been made time and again by men occupying high positions in the power-plant field. While the efficient central station will usually turn into power a larger percentage of the energy in the fuel than will the average isolated plant, it by no means follows that the shifting of a given power load from isolated plants to central stations will reduce the national fuel consumption. The author seems to have overlooked the economic significance of the employment of exhaust steam in isolated plants.

Engineering Foundation Annual Report, for the Year Ended Feb. 14, 1924, Ninth Year.—This report carries the pictures of the Four Founder Societies and gives a list of research projects with which the Engineering Foundation co-operated. Appendices are included in the report, giving the status of various of these projects. The abridged and partly rewritten report on the research conducted at the Engineering Experiment Station of the University of Illinois by H. F. Moore and T. M. Jasper, on "The Fatigue of Metals," is also included in this report.

"The Fatigue of Metals."—Third Report of the research at the Engineering Experiment Station of the University of Illinois by H. F. Moore and T. M. Jasper. Abridged and partially rewritten from Bulletin 142 of the Engineering Experiment Station of the University of Illinois, it forms a part of the Engineering Foundation Report for 1923-24.

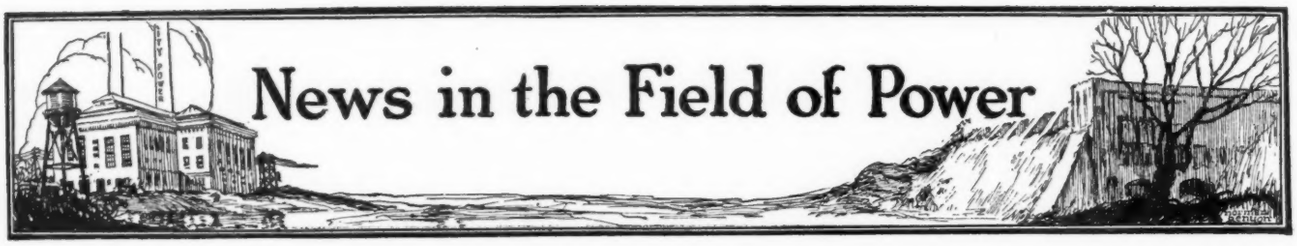
Perpetual Inventory and Stores Control, by Department of Manufacture, Chamber of Commerce of the United States, Washington, D. C. This little pamphlet, which has recently been revised, gives practical ideas on the perplexing question of inventories.

Portland Cement Prices; Their Basis, Character and Present Position. By Henry Parker Willis and John R. B. Byers. Published by the Ronald Press Co., New York City, 1924. Cloth, 5¼x7½ in.; 123 pages. Price, $1.25.

The Dominion Water Power Branch of the Department of the Interior, Canada has recently issued Bulletin No. 733, covering Water Power in the Mining Industry of Canada.

Central Electric Stations in Canada—Census of Industry, 1922. By the Dominion Bureau of Statistics. Printed by F. A. Acland, Ottawa. Price 25 cents.

Mechanical Refrigeration — Safe Practice Pamphlet No. 61. Published by the National Safety Council, 168 North Michigan Ave., Chicago, Ill.



Los Angeles Power Bond Issue Carries Nine to One

The sixteen-million-dollar power-bond issue submitted to the voters of the City of Los Angeles on Tuesday, Aug. 26, was carried by a sweeping majority. Virtually complete returns show 105,670 votes for the bonds and 12,783 votes against them. It will be recalled that two previous proposed issues have been defeated, one for $35,000,000 on June 19, 1923, and one for $21,000,000 in May, 1924. The sum of $16,000,000 now indorsed by the voters was fixed by the Railroad Commission, at the request of the city, as the amount reasonably necessary to carry out the three-year construction and betterment program of the city's Bureau of Power and Light.

Cherokee Bluffs Development To Have Six Dams

Permission to build six dams instead of four and to spend $39,000,000 instead of $28,000,000 at Cherokee Bluffs development in Alabama, was granted Aug. 27 to the Alabama Power Co., by the Alabama Public Service Commission.

This development will create an artificial lake on the Tallapoosa River covering 50,000 acres of lands, said to be the largest lake of the kind in the world.

The main dam at Cherokee Bluffs will be raised from 120 to 150 ft. and will be higher than the noted Mitchell Dam at Lock 12 on the Tallapoosa River, also owned by the Alabama Power Co.

In issuing this permission, the Alabama Public Service Commission calls attention, in its opinion, to the need for water-power legislation in Alabama, that a definite policy might be formulated. The certificate for the development on the Tallapoosa River is limited to 50 years.

Hetch Hetchy Water Bond Election Set

The San Francisco board of supervisors has passed an ordinance calling for a special election on Oct. 7, 1924, at which time the voters of the city will be asked to authorize the issuance of $10,000,000 in bonds to carry on the construction of the Hetch Hetchy water system of the city.

This bond issue will provide no funds for the purchase or construction of a municipal electrical distribution system for Hetch Hetchy power, it having been decided to postpone that matter until a later date when the Railroad Commission shall have fixed a valuation for condemnation proceedings on the distribution system of the Pacific Gas & Electric Co. and the Great Western Power Co. within the City of San Francisco.

The commission has been authorized to make such valuations, and hearings will soon be called in connection with this work. Work has been under way for some time. Approximately, $25,000 has already been spent and about $100,000 more will be required to complete the work. It is not expected that the findings of the commission will be handed in before the end of another ten months.

San Joaquin River Project To Generate 1,450,000 Hp.

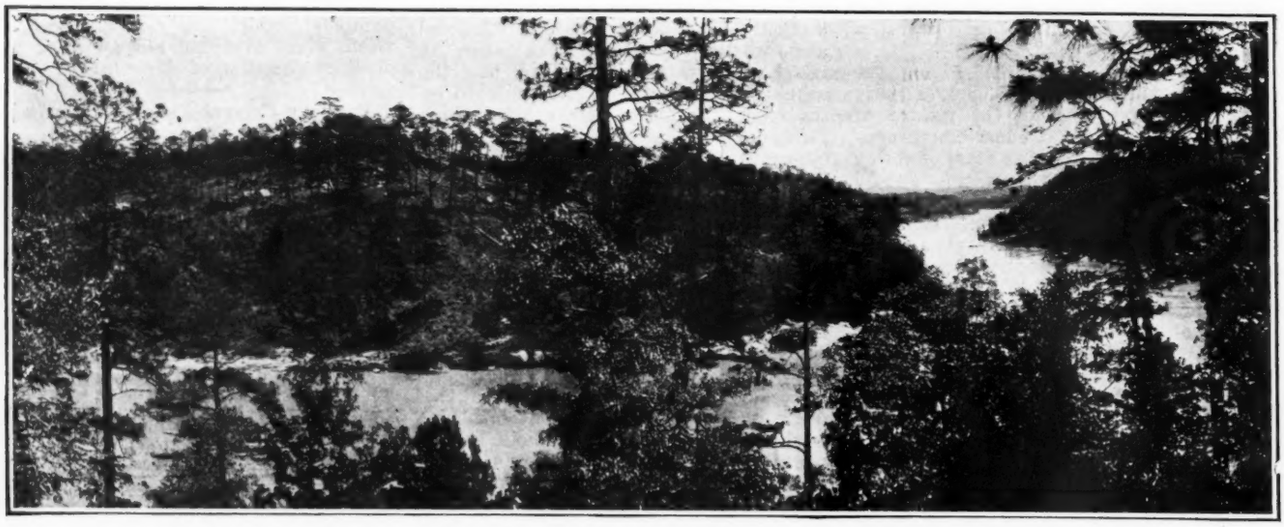
What is said to be the largest power project ever launched in California has received the state's official sanction through Edward Hyatt, Jr., acting chief of the division of water rights. This project, known as the San Joaquin River development plan of the Southern California Edison Co. calls for the construction of 17 huge power houses at a total cost of $200,000,000.

These power houses, according to the state Water Rights Departments, are authorized by 18 permits, which allow for unit development of the San Joaquin watershed above an altitude of 1,000 ft.

Fifteen huge storage reservoirs in connection with the power houses will, it is planned, generate 1,450,000 hp. and provide 680,117 acre-feet of storage. The storage thus obtained will be utilized to regulate the flow of the river uniformly throughout the year. In altitude these diversions reach 8,000 ft. maximum, while one power house is placed as low as 1000 feet.

"This project has yet to be approved by the federal government," Clyde L. Seavy, president of the California Railroad Commission, told a representative of *The Christian Science Monitor*. "There is no question as to its engineering features or legal validity. The commission may later be required to determine rates commensurate with cheapened power production which this great project should reasonably insure."

This huge project will be carried out in future years as the demand for power is created.



Cherokee Bluffs, Tallapoosa River, Ala., where the $39,000,000 power development will be located

Insull Interests to Control Brewer Utilities

Control of the American Public Utilities Co. has passed from Kelsey, Brewer & Co. to Samuel Insull and associates, the United Gas & Improvement Co., the Middle West Utilities Co. and the Midland Utilities Co., through ownership of the majority of the common stock, it was announced by Mr. Insull a few days ago. He stated that the American Public Utilities Co. will be operated as a separate holding company and that no consolidation with his other interests is in contemplation.

The American Public Utilities Co., which has had its headquarters at Grand Rapids, Mich., under the presidency of Joseph H. Brewer, is a holding company which through stock ownership controls the Central Indiana Power Co., the Merchants' Heat & Light Co. of Indianapolis, the Northern Indiana Power Co., the Indiana Electric Corp., the Wabash Valley Electric Co., and the Attica Electric Co., all serving Indiana cities and towns, and the Albion Gas Light Co., Albion, Mich.; Holland City Gas Co., Holland, Mich., and Utah Gas & Coke Co., Salt Lake City, Utah.

The Indiana subsidiaries give one or more classes of service to 135 cities and towns in twenty-seven counties, having a population of 550,000, and include a part of the business of Indianapolis and the entire business of the cities of Kokomo, Huntington, Noblesville, Wabash, Rochester, Clinton and Sullivan. Approximately 78 per cent of the companies' business is electric light and power. The Indiana Electric Corp., one of the subsidiaries, recently completed the first two units of the large power station on the Wabash River adjacent to large coal-land holdings of the company.

The total investment of all the acquired properties is put at $88,000,000. Gross earnings of subsidiaries of the American Public Utilities Co. for the twelve months ended June 30, 1924, were $7,760,631.

Power Dams and Fish Still Unsettled Question

To work out the possibilities of taking mature salmon over a high dam to the upper waters of the spawning rivers of the West, and then to get the young salmon down again, will be the purpose of experiments authorized by the Fish and Power Committee of Oregon and Washington at a meeting of that body in Portland on August 21. This committee, of which E. A. Simms of the Washington Fish Commission is chairman, was the outgrowth of the hearing in May attended by representatives of both the fish and power industries which was held in connection with the application of the Washington Irrigation & Development Co. to construct a 90-ft. dam across the Columbia River at Priest Rapids.

This project and others involving high dams across salmon-spawning rivers are being held up until it shall be satisfactorily demonstrated that the fish can without injury be passed over such dams. The Federal Power Commission has granted a preliminary permit for a development on the Klamath River in California over the protests of the California Fish Commission. It is maintained that the Chinook and other kinds of salmon cannot negotiate an ordinary fishway of greater elevation than 40 ft. so that the committee appointed to carry on the experiments is contemplating some form of elevator or escalator.

The first experiment, which will be under the supervision of John N. Cobb, director of the College of Fisheries of the University of Washington and executive secretary of the committee, will be conducted at the Condit dam of the Northwestern Electric Co. on the White Salmon River in Washington, a tributary to the Columbia. This dam, which is 125 ft. high, was chosen because of a fall run of Chinook salmon occurring in the White Salmon between September 15 and October 15 and because there is a ledge half way to the top from which it will be convenient to work in placing the temporary elevator framework. The Link-Belt, Meese, Gottfried Co., Seattle, has submitted a design of a one-basket conveyor which will be tried out.

The second phase of the experiment will be to see if the young fish can pass safely over the larger dams on their way down stream from the spawning grounds to the sea. Professor Cobb already has made experiments in passing them through a small turbine, and he now proposes to try sending them over the Snoqualmie Falls, where the result of a shear drop can be tested. He will also experiment in a like manner at some dam having an apron sloping down stream so as to ascertain how the fish take to this kind of a drop.

The results of the experiments will be watched with interest by both the fishing and power interests. Harmony between these interests is evident, and the preliminary expense of the experiments, amounting to $5,000, has been borne equally by both. Several of the larger power companies of the Northwest have subscribed their share of the $2,500 to be advanced by the power interests, and the fish commissions of the two states the balance.

The committee in charge of the experiments embraces besides Messrs. Simms and Cobb, J. E. Yates, assistant engineer Pacific Power & Light Co., Portland; W. D. Shannon, general superintendent Stone & Webster, Seattle, and Carl D. Shoemaker, Fish Commissioner of Oregon.

Hoover Says Many Consumers Have Not Bought Coal Yet

THE Department of Commerce issued its appeal to fuel consumers three months ago to lay in their winter supplies of coal during the summer months, Secretary Hoover said, in order to forestall congestion in transportation when cold weather arrived, in order to level operating time at the mines and so that consumers might benefit from the lower prices of summer. If a car shortage develops, it inevitably means higher prices of coal, he pointed out. Coal this summer has been cheaper than since 1916, said Secretary Hoover, adding that in his opinion some bituminous coal has been sold at a loss. The advice to stock during the summer was heeded by many consumers, he further stated, but was disregarded by many more, as evidenced by the fact that coal production this summer has been at the lowest rate in years.

While the railroads of the country appear to be in excellent condition to handle the fall crop movement, there may be more or less slight conflict with coal movement. The Secretary, however, did not predict a car shortage as a certainty, touching upon the subject only in a general discussion.

Utilities in Indiana Planning a Merger

Plans for the consolidation of fifteen electric light and power and gas companies serving fifty cities and smaller communities in northern Indiana are outlined in a petition filed with the Public Service Commission of Indiana.

Under the proposed merger plan the Calumet Gas & Electric Co., with headquarters in Gary, will purchase fourteen other public utilities and merge their properties with its own. Samuel Insull is president of the Calumet Gas & Electric Company and Charles W. Chase of Gary is vice-president.

The utility companies in question are the Knox Electric Light & Power Co., Monterey Light & Power Co., North Judson Electric Co., Plymouth Electric Light & Power Co., LaGrange County Light & Power Co., Valparaiso Lighting Co., Consumers' Electric Co., Demotte Utilities Co., Hanna Light & Power Co., Kankakee Valley Electric Co., Kingsbury Light & Power Co., Union Electric Co., Wanatah-La Crosse Electric Co. and the Elkhart Gas & Fuel Co. Some of these companies have been under the control and management of Mr. Insull and associates for some time, others having been acquired since the first of this year. By consolidating them it is expected that economies and more efficient operation will result because of centralized supervision.

Most of the companies furnish electric light and power service, the only exclusively gas property being in Elkhart. The Valparaiso Lighting Co. furnishes gas as well as electric service. The companies operate in twelve counties in the north end of the state. Communities served are in Lake, Porter, Laporte, St. Joseph, Elkhart, Newton, Starke, Marshall, Fulton, Pulaski, LaGrange and Noble Counties. Some of the important towns served, besides Elkhart and Valparaiso, are East Gary, Crown Point, Lowell, Plymouth, Culver, Knox, North Judson, LaGrange and Wolcottville. These towns served are interconnected by an extensive electric transmission system, which with the local distribution systems totals 456 miles.

Will Increase Power Output at Roosevelt Dam

According to recent press reports a new issue of bonds for power development of the Roosevelt Dam has been awarded.

The Salt River Valley Water Users' Association, which operates the Roosevelt Dam, built by the United States Reclamation Service, are getting the loan in order to complete the hydroelectric development for power purposes.

The present capacity of the dam is 21,000 h.p., which will be increased to 70,000 h.p. by the additions contemplated.

Severn Tidal Dam for Power Still Being Considered

The Severn tidal barrage or dam scheme for the production of electrical power, which was first discussed soon after the war but was later dropped, is again receiving public attention, according to recent press reports.

Briefly stated, the tide rushing through the sluices into the huge reservoir will drive the machinery, which can be kept running when the tide ebbs and by the water flowing out again.

The government has decided to proceed immediately with the preliminary investigations. The great scope of the whole scheme may be judged from the fact that these preliminaries alone will cost about $475,000. The Chancellor of the Exchequer, Philip Snowden, speaking of unemployment in the House of Commons in July, forecast a revision of the scheme which, he said, if carried through successfuly, would rank as one of the most difficult engineering feats in the world's history. The Severn estuary is the largest in Britain, and tides have a rise and fall from 30 to 40 feet.

A committee of experts has been appointed under the chairmanship of G. S. Albright, to consider the feasibility of the scheme, which rests on the possibility of finding satisfactory foundations for the barrage, so that the first problem involves the geological consideration of determining the contour of the river bed and the preliminary measurements of the flow of the water at different stages of the tide. In addition to the committee, two eminent engineers, Sir John Purser Griffith and Sir Maurice Fitzmaurice, have been invited to submit a joint report by the end of the year as to the possibility of building the barrage on the suggested sites, assuming that safe foundation exists.

When this scheme was first put forward, the cost was estimated at $150,000,000. Other questions that are certain to come up are the effect on the ports of Cardiff, Avonmouth and Bristol, interests also in fishing and whether the enormous initial cost is likely to be justified by the returns.

N.A.S.E. Convention at Grand Rapids Sept. 9-12

Technical Papers Program

"Labor and Horsepower, Here and Abroad," by Charles M. Ripley.

"Twoscore Years of Power Development," by Fred R. Low.

"Applications of Pulverized Fuel in the Newest Power Plants," by Frederick A. Scheffler.

"Automatic Combustion Control Systems," by Charles H. Smoot.

"Operation of Large Unit Boilers at High Ratings," by Dr. Edgar Kidwell.

"New Type Synchronous-Induction Motors," by Val A. Fynn.

"The Diesel Engine as a Prime Mover," by Lacey H. Morrison.

"The Diesel Power Plant," by Louis R. Ford.

"Boiler Room Instruments," by E. G. Bailey.

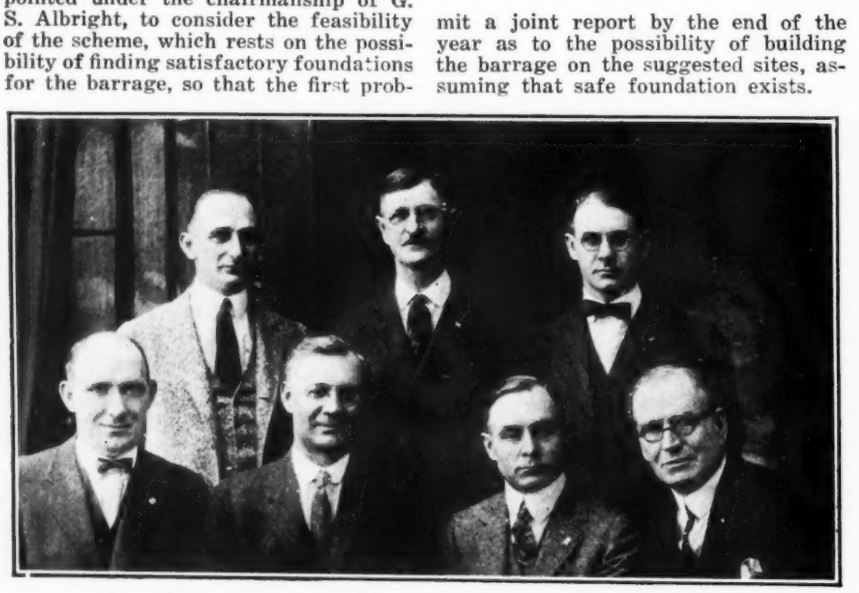
"Recent Developments in Ice and Refrigerating Plants," by Halbert P. Hill.

"Electrically Operated Flow Meters," by J. M. Spitzglass.

"What Can the N.A.S.E. Do For the American Operating Engineer?," by Thomas G. Thurston.

"How Can our State Associations be Made More Effective?," by James H. Heath.

Twenty-minute talk by a representative of the International Correspondence Schools of Scranton, Pa., on "Co-operation of the School with the N.A.S.E."



Committee in Charge of the National Convention, N.A.S.E. at Grand Rapids, Mich., Sept. 8-12

Back row, left to right—O. J. Dykman, W. H. Yeomans, H. W. Johnson. Bottom row, left to right—F. J. Gleason, George J. Burtiss, Jack Chalmers, William Gormley

Production of Bituminous Coal Increases

The production of soft coal was materially improved in the week ended Aug. 23, and passed the 8,000,000-ton mark for the first time since last March, according to the Department of Interior. The total output, including lignite, coal coked, mine fuel and local sales, is estimated at 8,293,000 net tons, an increase of 384,000 tons, or nearly 5 per cent.

The trend in the rate of production appears to have turned definitely upward, and preliminary telegraphic reports on loadings on the first two days of the week, Aug. 25-30, show an increase of nearly 2 per cent over the total for the corresponding days last week.

Production of bituminous coal in July aggregated 32,284,000 tons, as contrasted with 30,447,000 tons in June and 45,126,000 tons in July, 1923. Antracite production in July amounted to 7,782,000 tons, as against 7,704,000 tons in the previous month and 8,320,000 a years ago. Total coke production aggregated 2,818,000 tons in July, as compared with 2,971,000 tons in June and 4,848,000 tons in July of last year, according to government statements.

Budget Director May Cut Research Appropriation

The ax is being used ruthlessly by the Director of the Budget on the estimates for federal expenditures now being submitted, it is understood. Some 97 per cent of the expenditures of the federal government are in connection with past wars and in the preparation for possible future wars. The remaining 3 per cent is devoted largely to so-called welfare service in the interest of industry or other form of work from which the public benefits. The chief drive seems to be against this 3 per cent. Unless Congress overrides the budget, a large amount of experimental and research work will have to be discontinued during the next fiscal year.

An insidious feature of these cuts in the estimates is the fact that no one is allowed to reveal the reductions that are being made. Could industry be advised of certain reductions at this time, steps could be taken that would insure bringing the matter to the attention of enough members of Congress in the hope that they would have more vision than has the Director of the Budget and would continue appropriations for important research. It is said that reductions are being made by adding machine methods. No account is being taken of the importance of the work, but certain lump sums are prescribed as the reductions that must be made.

Mexico Imports Considerable Power Machinery

Commerce Reports publishes the following table, which gives American exports of purely industrial machinery to Mexico for the years 1922 and 1923, according to the United States customs returns:

UNITED STATES EXPORTS OF INDUSTRIAL MACHINERY TO MEXICO

Class	1922	1923
Power generating machinery, except electric	$1,221,953	$1,042,695
Construction and conveying machinery	438,599	536,754
Mining, oil-well, and pumping machinery	2,641,830	2,488,823
Miscellaneous other machinery, except agricultural	3,743,025	2,915,177

Michigan Increases Efficiency of Steam Plant Operation

Michigan has increased its output of hydro and steam generators to such an extent that it now ranks sixth among the states in electrical production, according to figures published by the Geological Survey.

During 1923 the increase in electrical output outstripped its previous advances. The amount generated during 1923 is reported as 2,580,399,000 kw.-hr. This is said to be about one-twentieth of the electrical output of the United States.

The hydro-electric increase for 1923 is rated at 48,494,000 kw.-hr. over the output of 1920. The increase from steam generators is given as 439,041,000 kw.-hr.

Increased efficiency in steam-plant operation is shown in the report. In 1919 it required 3.2 lb. of coal for Michigan's steam plants, per kilowatt-hour. More efficient boilers, turbines, and generators have resulted in lowering this proportion to 2.4 lb. of coal per kilowatt-hour in 1923.

Tidal Power Plant Plans for Aberwrach, France

According to recent press reports, a definite step toward the realization of the employment of the tides for generating electricity on a considerable scale has been taken. A decree in the *Journal Officiel* affirms that public utility works will be begun at Aberwrach on the coast of Brittany.

The State will contribute 10,000,000 francs, about half the estimated cost of the annual production of 11,000,000 kw.-hr., corresponding to the power which would be given by 16,500 tons of coal. There has been much talk of this scheme, and various experiments had been made, but it was waiting for financial arrangements.

Whether power can be successfully obtained from the sea is a question that will be watched with the greatest interest. Commercially, it is declared that the amortization of capital and the cost of exploitation will certainly be very much lower than 5,000,000 francs, which 16,500 tons of coal would cost. It is calculated that current can be delivered at a small price. The development consists of the construction of a barrage on which will be a building containing hydraulic turbines. It will be 150 yards long and four yards above the highest tides. There will be four turbines, each developing at greatest pressure 1,200 hp. To assure regularity in the supply of energy, a second barrage will be built for low tides.

If Aberwrach gives satisfactory results, an immense field will be opened to activity and ingenuity.

Chemists Study Coal Storage and Spontaneous Combustion

The American Chemical Society, at its meeting at Ithaca, N. Y., Sept. 8-13, will hold a "Storage of Coal and Spontaneous Combustion Round Table Discussion." The papers, summarized briefly, for starting discussion are:

S. W. Parr, "Deterioration and Spontaneous Combustion of Coal in Storage." The conditions concerning the heating of coal in storage may be summarized as follows:

A high percentage of textural moisture in a coal indicates a high capacity for oxygen absorption. Such coals immediately upon breaking out from the seam begin to lose moisture until an equilibrium with the moisture of the atmosphere is established, thus making way for the accession of oxygen.

The larger the lumps of coal the slower the interchange as between the free or inherent moisture and oxygen. Conversely, the more finely divided the material the more rapid the interchange and also the greater the superficial area of the coal particles.

Accessibility of air within the coal mass, thereby augmenting the supply of oxygen beyond the amount taken up by absorption, is essential for carrying the oxidation forward, thus bringing the temperature of the mass up to the point of ignition.

Accessibility of air involving ready circulation to an extent which will carry away the initial increments of heat as rapidly as formed will prevent a rise of temperature.

Complete prevention of an additional oxygen supply beyond that absorbed by the coal before entering the storage pile will insure against any appreciable or dangerous rise of temperature.

The oxidation of pyritic sulphur requires the presence of free moisture as well as oxygen. The augmenting of the heat in any manner greatly accelerates the oxidation processes for both the hydrocarbon and the sulphur components of the coal.

N. R. Beagle, "Deterioration of Mid-West Coals Under Different Storage Conditions—Effect on Burning Qualities."

The biggest single item of operating expense of a public-utility property electric generating station is coal.

The Illinois Power & Light Corp., operating electric generating stations in six of the Midwest States, consumes a total of about 1,000,000 tons of coal per year. In order to safeguard service, it is necessary to store coal at some twenty different points, and the amounts vary up to as high as three to four months' supply.

Methods used for storing coal cover under water storage in pits, and above ground open storage in a good many sizes, shapes and depths of piles. Mainly screenings up to 2-in. in size are stored, these coming from the different fields of Illinois, Kentucky, Kansas and a small amount from Iowa.

Storage coals in some cases show very low heat-value loss, while under other conditions of storage deterioration seems to be more rapid, resulting in firing and wastage due to repiling. Data are given covering above coals and methods of handling.

Practically all stored coals are burned on chain-grate stokers, using natural draft. Observations are given covering differences in burning various newly mined screenings and in burning the same coals after holding in storage over periods of time. General observations cover tests made on different slack piles, fine waste coal piles, etc.

Conclusions are given covering methods found most satisfactory for open storage above ground to minimize heating and deterioration, also methods found most satisfactory at the power plants to follow in obtaining maximum efficiency when storage coals are burned.

J. D. Davis and John F. Byrne, "Spontaneous Combustion of Coal—Characteristics Shown by an Adiabatic Calorimeter."

S. W. Parr and R. T. Milner, "The Oxidation of Coal at Storage Temperatures."

Coal samples were carried in parallel through a two months' period in an atmosphere of oxygen at varying temperatures. A log of the weights of the sample and the water and carbon dioxide discharged was kept. The striking fact developed that the samples throughout the time consistently increased in weight, notwithstanding the combined weight of the discharged water and carbon dioxide was approximately twice that of the oxygen absorbed. The main factor is the temperature to which the coal mass is subjected. The mechanism of oxygen behavior on stored coal seems to be indicated and many discrepancies explained as to the loss of heating value due to stocking of coal.

S. W. Parr and E. R. Hilgard, "The Oxidation of Sulphur as a Factor in the Storage of Coal."

A review of the situation concerning sulphur as an initial source of heat for the starting of spontaneous combustion points out that finely divided pyritic sulphur even in microscopic sizes is more common than had been supposed. Also the high percentage of sulphur often found associated with mother of coal is noted, and finally a study of some of the Illinois coal measures makes it evident that sulphur in the marcasitic form is quite as abundant as in the pyritic form.

Since the oxidation of so small an amount of sulphur is 0.5 per cent may raise the temperature of the mass through 71 deg., it is evident that further attention should be given to sulphur and the rôle it may play in the starting of spontaneous combustion difficulties in stored coal.

S. W. Parr and C. C. Coons, "Carbo Dioxide as an Index of the Critical Oxidation Temperature for Coal in Storage."

The discharge of carbon dioxide from

coal subjected to a current of oxygen and maintained at varying temperatures has been studied and an apparatus described for its measurement. The facts brought out in the investigation of various coals by the use of the device are helpful in that the degree of chemical activity of oxygen at various temperatures is readily shown. Especially important is the point shown at which the temperature due to oxidation within the coal passes the temperature of the surrounding air. From this point the oxidation becames autogenous and is not dependent for its continuation upon the supply of external heat. This is designated as the critical oxidation temperature and in a coal pile would be practically synonymous with the temperature of ignition. This critical temperature varies with the type of coal and other minor factors but its chief significance is its relatively low range for most bituminous coals, approximately 140-150 deg.

Discussion will be continued by W. D. Langtry, W. H. Fulweiler, and T. E. Layng.

A.I. & S.E.E. Convention Program

The Association of Iron & Steel Electrical Engineers, which will hold its meeting at Duquesne Garden, Pittsburgh, Pa., Sept. 16-19, will have various papers of interest to *Power* readers. They are:

"Adjustable Speed Sets for Rolling Mills," by L. A. Umansky; "Combustion Control," by E. G. Bailey; "Electric Heating with Special Reference to Central Stations," by E. D. Sibley; "Development in Electric Repair Shop Practice," by A. C. Cummins; "Crane Hoists Travel Limit Devices," by Walter Greenwood; "Machine Tools and Their Auxiliaries," by John F. Kelly; "The Steel Industry and the Electric Utilities," by Merrill Skinner and F. D. Mahoney; "Power in the Iron and Steel Industry in America," by Barton R. Shover.

A.E.S.C. Announces Approval of Codes

The American Engineering Standards Committee is announcing the approval as Tentative American Standards of the A. S. T. M. "Specifications for Welded and Seamless Steel Pipe and Welded Wrought-Iron Pipe." The A. S. T. M. initiated work on specifications for steel pipe in 1915 and for wrought-iron pipe in 1918. In 1921 the work broadened to include seamless as well as welded pipe and was modified to bring them in accordance with the "American Standard Pipe Thread."

The 1914 A. S. M. E. "Standard for Cast-Iron Flanged Pipe and Fittings for 125 Lb. Steam Pressure" is now in revised galley-proof form and undergoing a vote of the sectional committee. Work has been done on preparation of "Standards for Steel Flanges and Flanged Fittings for 200, 400, 600 and 900 Lb. Steam Pressure with 750 Deg. Superheat."

The "Tentative Safety Code for Laundries," has been approved. This code, which was formulated by a sectional committee under the joint sponsorship of the Association of Governmental Labor Officials, the Laundry Owners National Association and the National Association of Mutual Casualty Companies is being published by the U. S. Department of Labor.

Electric-Steam Generator Conserves Coal

Coal savings estimated at 3,000 tons per year are looked for from the installation of an electric-steam generator recently ordered by the St. Croix Paper Co., at Woodland, Me. Improved power factor and the utilization of spring and fall high water are expected to result from other up-to-date electrical machinery now being installed in this plant.

The hydro-electric plant of this company is on the St. Croix River and is 12 miles from the company's mill. A G. E. 3,360-kw., 2,400-volt vertical waterwheel generator is now being installed to be used as a spare unit and to permit the utilization of high water in the spring and fall for the generation of excess power. This excess power may be used either for the making of wood pulp or for running the electric-steam generator. Wood pulp made in this manner during the flood season will be stored away as dry-pulp laps and be made into paper during the dry summer and fall months.

Officials of the St. Croix Co. and G. E. engineers estimate that the new generator may produce as high as 15,000,000 kw-hr. excess power at high-water periods with a normal rainfall. By putting this power into the electric-steam generator they expect a saving of approximately 3,000 tons of coal a year. The steam generator is to be installed in the boiler house and will be piped into the main steam line, supplementing the coal-fired boilers. Steam necessary to heat the mills on Sundays and holidays, when the motor load is shut off will come from the electric-steam generator, and the load curve of the mill will be ironed out by having the steam generator take up the variations in electrical load on the mill from time to time.

An 1,800-hp., 2,200-volt synchronous grinder motor, to be directly coupled to pulp grinders, is also being installed. Present wood grinders at the paper mill are part motor-driven and part water-wheel-driven and are of the pocket type. The new motor will also drive pocket grinders, but will be so arranged that magazine grinders may be installed later. In addition to the necessary switchboard equipment, a 6,000-kva. transformer has been ordered to step down the voltage from 33,000 to 6,600 for use in the electric-steam generator. The electrical machinery already installed, as well as the new equipment was made by the G. E. Co.

Three definite results are expected by the St. Croix officials: Power-factor correction by the synchronous grinder motor, the utilization of otherwise waste energy by working up raw material in advance of requirements, and the substitution of a certain amount of electrically generated steam for the steam ordinarily produced by burning coal.

July Export of Oil Shows Big Gain

The Department of Commerce announces a large increase in the amount of oil exported during the first seven months of 1924. Practically every class of oil products exported recorded a gain in both value and quantity during July. The figures in detail for 1924 as compared with 1923 are:

	July, 1924 Gal.	July, 1923 Gal.
Crude oil	57,720,557	63,755,613
Gas and fuel oil	135,293,476	98,064,819
Lubricants	24,870,703	22,693,214
Seven months ended July 31:	1924	1923
Crude oil	454,239,664	389,110,619
Gas and fuel oil	829,807,553	659,950,536
Lubricants	237,411,888	215,474,659

Junior Engineers Wanted by the Government

The United States Civil Service Commission announces an open competitive examination for junior engineer.

The examination will be held throughout the country on Oct. 8. It is to fill vacancies in the Bureau of Standards, Bureau of Mines, Bureau of Chemistry, and various other branches of the government service, at an entrance salary of $1,860 a year. Advancement in pay may be made without change in assignment up to $2,400 a year. For appointment outside of Washington, D. C., it is probable that this same rate of pay may be applicable, but if not, the entrance salary will be from $1,500 to $2,000 a year.

Examination will be given in the following optional subjects: Aëronautical engineering; chemical engineering; civil engineering; electrical engineering; highway engineering; hydraulic engineering; mechanical engineering; mining engineering; petroleum engineering; and radio engineering.

Competitors will be rated on general physics, pure and applied mathematics, practical questions on the optional subjects selected, and education, training, and experience.

Full information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post office or custom house in any city.

The aggregate motive equipment of the industrial undertakings in the Union of South Africa represents 1,750,000 hp. Steam is still the leading form of power in use, but the application of electricity was increased 30 per cent in the last three years, while the use of steam power increased only 7 per cent during the same period.

Personal Mention

Carl M. Hoskinson has just been appointed, by the city engineer of Sacramento, chief engineer of the pumping station.

Morris L. Potts, mechanical engineer, has severed his connection with the United Gas Improvement Contracting Co., of Philadelphia, where he was en-

gaged on electric power plants design. He has moved to Los Angeles, Calif., where he will devote his time to the hydraulic and oil engineering fields.

Trade Catalogs

Hoist—Motorbloc Corp., Summerdale, Philadelphia, Pa. Bulletin "The Motor Driven Chain Hoist," describes and pictures this hoist.

Stokers—United Stokers Co., La-Porte, Ind. A 20-page catalog outlining the salient features of design of the United natural draft stokers, has been issued by this company.

Turbines—The Standard Turbine Corp., Scio, N. Y., is publishing *The Standard Turbine Bulletin*, a monthly publication which contains articles of interest on turbines by engineers of the company.

Coal Spreader—Universal Coal Spreader Co., 53 West Jackson Blvd., Chicago. An eight-page pamphlet has been issued showing the construction and pointing out the advantages in the use of this device with the various types of stoker.

Fans—American Blower Co., Detroit, Mich. The August Bulletin, No. 1103, which has just been published, gives descriptive drawings of the assembly and details of these fans and has also many tables of data of capacities and dimensions beside concise textual descriptions.

Stokers—Illinois Stoker Co., Alton, Ill. The third edition of Catalog "L," besides being well illustrated, discusses the advantages of mechanical stoking, the fundamental advantages of the chain-grate stoker, air control, merits and advantages of the Illinois natural and forced-draft chain-grate stokers.

Furnace Cements—The S. Obermayer Co., 2563 West 18th St., Chicago. A 24-page pamphlet has just been issued giving the characteristics and telling where and how to use the company's high-temperature furnace cements, designated as Hott-Patch, Esso Bond, Esso No. 33, Esso Bond No. 40, and Ramtite plastic monolithic furnace lining material.

Material Handling Systems—The Stearns Conveyor Co., East 200th St. and St. Clair Ave., Cleveland, Ohio. A comprehensive catalog has just been issued by this company, covering its various conveyors, screens, elevators and carriers. The illustrations of installations, charts, photographs, tables, drawings and descriptions show the usefulness of these conveying machines in every line of industry.

Chains and Conveyors—Chain Belt Co., Milwaukee, Wis. Rex Chains and Conveyors, No. 210, is the title of a 512-page cloth-bound catalog and engineering data book presenting the complete company lines of Rex chain, conveying machinery and concrete mixers, with an engineering section devoted to design, construction and various tables. The book is indexed and fully illustrated to show the wide range of application of the company's material handling equipment.

Coming Conventions

American Ceramic Society. Ross C. Purdy, Lord Hall, Ohio State University, Columbus Ohio. Convention at Los Angeles, Calif., Oct. 6-7.

American Chemical Society. Dr. Charles L. Parsons, 1709 G St., N. W., Washington, D. C. Sixty eighth meeting at Cornell University, Ithaca, N. Y. Sept. 8-13.

American Electric Railway Association. James W. Welsh, 8 West 40th St., New York City. Meeting at Atlantic City, Oct. 6-10.

American Electrochemical Society. Dr. Colvin G. Fink, Columbia University, New York City. General meeting at Detroit, Mich., Oct. 2-4.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Fall convention at Pasadena, Calif., Oct. 13-17.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Autumn meeting at Birmingham, Ala., Oct. 13-15.

American Society of Civil Engineers. 29 West 39th St., New York City. Fall meeting at Detroit, Oct. 23-25.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 1-4.

American Society of Refrigerating Engineers. W. H. Ross, 35 Warren St., New York City. Annual meeting at New York City, Dec. 1-3.

Association of Edison Illuminating Companies. P. S. Millar, 80th St. and East End Ave., New York City. Meeting at Griswold Hotel, New London, Conn., Sept. 8-12.

Association of Iron & Steel Electrical Engineers, John F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Annual meeting and exposition at Duquesne Garden, Pittsburgh, Pa., Sept. 15-20.

Eastern Ice Manufacturers Association. W. H. Ross, 35 Warren St., New York City. Eighteenth annual meeting at Hotel Chelsea, Atlantic City, N. J., Nov. 12-14.

Electric Power Club. S. N. Clarkson, B. F. Keith Bldg., Cleveland, Ohio. Fall meeting at Greenbriar, White Sulphur Springs, W. Va., Oct. 20-23.

Exposition of Chemical Industries. F. W. Payne, Grand Central Palace. Tenth Exposition at Grand Central Palace, New York City, Sept. 28-Oct. 3, 1925.

Franklin Institute of Pennsylvania, Centenary Celebration at Philadelphia, Sept. 17-19.

Illuminating Engineering Society. Norman D. MacDonald, 29 West 39th St., New York City. Convention at Briarcliff Lodge, Briarcliff Manor, N. Y., Oct. 27-31.

International Union of Steam and Operating Engineers. Dave Evans, 6334 Yale Ave., Chicago, Ill. Biennial convention at Detroit, Mich., Sept. 8-13.

National Association of Practical Refrigerating Engineers. E. H. Fox, 5707 West Lake St., Chicago, Ill. Convention at New Orleans, La., Nov. 11-14. Exhibits at the Isaac Delgado High School.

National Association of Stationary Engineers. Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Hotel Pantlind, Grand Rapids, Mich., Sept. 8-13.

National Exposition of Power and Mechanical Engineering. C. F. Roth, Grand Central Palace, New York City. Annual exposition at New York City, Grand Central Palace, Dec. 1-6.

National Safety Council. W. H. Cameron, 168 N. Michigan Ave., Chicago, Ill. Thirteenth Annual Safety Congress at Louisville, Ky., Sept. 29 to Oct. 3.

New England Water-Works Association, Frank T. Gifford, 715 Tremont Temple, Boston, Mass. Annual convention at Powers Hotel, Buffalo, N. Y., Sept. 23-26.

Instruments, Electrical Measuring—The Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. Catalog No. 48 "Apparatus for Measuring Conductivity of Electrolytes," contains descriptions of typical equipments, instruments and accessories and gives the method for measuring electrolytic resistance, the factors affecting accuracy, and selection of cells, as well as a good bibliography.

Pumps—The Aldrich Pump Co., Allentown, Pa. Pumps Data No. 50 gives engineering tables on heads, equivalents, capacities, friction loss, equalizing pipes, input of horsepower necessary at various efficiencies, Baumé scale, specific gravities, table of degrees Brix, effective fire streams, horsepower transmitted by leather belting, transmitting efficiency of steel shafting at different speeds, electrical data, conversions table, water required per minute to feed boilers, cost of pumping, dimensions of pipes, bolts, flanges, and many other useful tables.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Aug. 25, 1924	Aug. 30, 1924
Pool 1	New York	$2.85	$2.90
Smokeless	Columbus	2.00	2.15
Clearfield	Boston	1.85	2.35
Somerset	Boston	2.10	2.40
Kanawha	Columbus	1.40	1.55
Hocking	Columbus	1.55	1.65
Pittsburgh No. 8	Cleveland	1.80	1.85
Franklin, Ill.	Chicago	2.35	2.50
Central, Ill.	Chicago	2.20	2.25
Ind. 4th Vein	Chicago	2.35	2.50
West Ky.	Louisville	1.60	1.85
S. E. Ky.	Louisville	1.50	1.75
Big Seam	Birmingham	1.75	2.00

FUEL OIL

New York—Sept. 4, light oil, tank-car lots, 28@34 deg. Baumé, 4¾c. per gal., 36@40 deg. 5c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Aug. 26, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.50 per bbl.; 26@28 deg., $1.55 per bbl.; 28@30 deg., $1.60 per bbl.; 30@32 deg., 4¼c. per gal; 32@36 deg., gas oil, 5c. per gal.; 38@40 deg., 6c. per gal.

Pittsburgh—Aug. 27, f.o.b. local refinery, 30@34 deg., fuel oil, 5¼c. per gal.; 36@40 deg., fuel oil, 5½c. per gal.; 34 deg., neutral, 8½c. per gal.

Dallas—Aug. 30, f.o.b. local refinery, 26@30 deg., $1.15 per bbl.

Philadelphia—Aug. 29, 28@30 deg., $2.05@$2.113 per bbl;. 18@22 deg., $2.075@$2.139; 13@16 deg., $1.78½@$1.848 per bbl.

Boston—Sept. 1, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4¼c. per gal., light oil, 28@32 deg. Baumé, 5¾c. per gal.

Cincinnati—Sept. 2, tank-car lots, f.o.b. local refinery, 24@26 deg., Baumé, 4¾c. per gal.; 26@30 deg., 4¼c. per gal.; 30@32 deg., 5c. per gal.

Chicago—Aug. 30, 20@22 deg., 5¼c. per gal.; 24@26 deg., 6c. per gal.; 28@30 deg., 6c. per gal.

New Plant Construction

Ala., Florence—U. S. Engineers' Office will receive bids until Sept. 12, for furnishing one 10-ton electric traveling crane, motors 440 volt, three-phase, 60 cycle for power house at Wilson Dam.

Calif., Los Angeles—F. W. Braun, Braun Bldg., is having plans prepared for the construction of a 12-story hotel on Benton and Wilshire Blvds., estimated cost to exceed $1,500,000.

Calif., Los Angeles—Los Angeles Ice Skating Assn., c/o J. M. Cooper, Marsh-Strong Bldg., Archt., is having plans prepared for the construction of an 80 x 180 ft. ice skating rink on Melrose Ave.

Calif., San Francisco—The Pacific Gas and Electric Co., 445 Sutter St., awarded the contract for 160 tons of steel for compressor house at 23rd and Illinois Sts.

Calif., Tracy—Banta-Carbona Irrigation District, W. Schlossman, Secy., is receiving bids until Sept. 17th for furnishing and installing 6 pumping plants as follows: 7 centrifugal pumps of 20 cu.ft. per sec. capacity, 14 centrifugal pumps of 40 cu.ft., 21 motors, starters, relays, float switches, etc. W. D. Harrington, Tracy, is engineer.

Conn., Durham—The Durham Aqueduct Co. plans the construction of a pumping station and artesian well, cost to exceed $25,000.

Conn., New Haven—The New Haven Gas Light Co. is building a 3,000-hp. boiler plant. The plant has been designed to burn coke breeze, special conveying, crushing and burning equipment will be required.

Fla., Miami—Dept. of Public Utilities will build a 10 million gal. water softening plant by city labor. Owner will purchase 2—10,000,000 gal. and 1—15,000,000 gal. centrifugal pumps. A. Burdick & Howson, 7 S. Dearborn St., Chicago, is engineer.

Fla., Miami—J. R Dorn plans the construction of a 14 story, 100 x 150 ft. office building at 221 N. E. 1st Ave., estimated to cost $600,000.

Ill., Chicago—Hotel Sherman Co., Clark and Randolph Sts., awarded the contract for the construction of an 8-story, 70 x 182 ft. addition to hotel on Randolph St., to G. A. Fuller Co., 140 S. Dearborn St., and a 22-story, 80 x 182 ft. service building on Lake St., to Krahl Construction Co., 350 N. Clark St., total estimated cost $7,000,000. Holnbird and Roche, 104 So. Michigan Ave., are architects.

Ind., Anderson—Board of Public Works is receiving bids until Sept. 8 for construction of pipe line to North Anderson. Pumps will be required. Estimated cost $65,000. M. H. Downey, City Hall, is engineer.

Kan., Kansas City—The City Water Works Dept. is having plans prepared for enlarging the plant 50 per cent, estimated to cost $900,000. Steam boilers and generators will be required. J. D. Donavan, c/o Water Works Dept., is chief engineer.

Ky., Louisville—Red Star Yeast & Products Co., 79 Buffalo St., Milwaukee, awarded the contract for the construction of a 1-story, 52 x 130 ft. service building, estimated to cost $50,000. Ice machine will be required. E. R. Tiebert, 432 Broadway, Milwaukee, is architect.

La., Berwick—Board of Aldermen and S. Watkins, mayor, will receive bids until Sept. 16 for water works and electric light improvements, including two 100-hp. oil engine generator sets, one motor-driven pumping equipment, switchboard apparatus, street lighting system, one 50,000 gal. elevated steel tower and tank, power and pumping service station buildings, mechanical filter plants, etc. H. Mentz, Magnolia, Miss., is consulting engineer.

Mass., Boston—The Anchor Laundry Co. plans the construction of a boiler house at 95 Freeport St.

Mass., Boston—City Hospital Dept., J. P. Manning, president, 181 Harrison Ave., are having plans prepared for the construction of a 9-story hospital building, estimated to cost $750,000. Ritchie Parsons & Taylor, 15 Ashburton Place, are architects.

Miss., Marks—Quitman Co. Light & Power Co. plans to rebuild plant destroyed by fire.

Miss., Pass Christian—S. L. McGlathery, Miramar Hotel, is having plans prepared for the construction of a 5-story, 55 x 175 ft. hotel, estimated to cost $500,000. W. C. Keenan, Liverpool, London & Globe Building, Common and Carondelet Sts., New Orleans, is architect.

Mo., Kansas City—J. N. McConnell, c/o R. Cornall, 203 Bruening Bldg., architect, awarded the contract for the construction of an 8-story, 60 x 150 ft. hotel to Collins Bros., 1600 Grand Ave., estimated to cost $500,000.

Mo., St. Louis—Schoelch Designing & Engr. Co., 1214 Syndicate Trust Bldg., are preparing preliminary plans for the construction of a 12-story, 105 x 170 ft. office building on Grand Blvd. and Franklin St., for a local syndicate, estimated to cost $1,000,000.

Mo., Sedalia—City Water Co. plans centrifugal and pumping machinery, mechanical equipment, extension and improvements to plant, estimated to cost $300,000.

Neb., Omaha—Wade and Crosby, Chicago, Ill., architects, are receiving bids until Sept. 16, for a 17-story, 60 x 132 ft. Medical Arts Building on 17th and Dodge Sts., for B. Kulp, 3158 West Madison St., Chicago, Ill. Estimated cost $1,000,000.

N. J., Little Falls — The Township is having plans prepared and will receive bids about Oct. 15th for extension of the sewage system and the construction of a sewage pumping station. H. J. Harder, 129 Market St., Paterson, is engineer.

N. J., Princeton—Day & Klauder, Franklin Bank Bldg., Phila., Pa., architects, are receiving bids until Sept. 10 for a 1-story, 51 x 110 ft. boiler house for Princeton University.

N. Y., Auburn—City Hospital awarded the contract for the construction of three 4 story buildings and altering present buildings to F. T. Ley Co., 230 Boylston St., Boston, Mass., estimated to cost $500,000. Hillger & Tallman, 96 Genessee St., are architects.

N. Y., Brooklyn—Bureau of Yards and Docks, Navy Dept., Washington, D. C., will receive bids until September 17th, for incinerator plant and modifications of power house for installation at the Naval Hospital, here. Spec. No. 5021.

N. Y., Kings Park—The City Hospital Commission, Albany, will soon award contract for an addition to powerhouse at the Kings Park State Hospital, estimated to cost $500,000.

N. C. Greensboro—The City plans to increase the pumping capacity of present water plant, machinery will be installed to give city 8,000,000 gallons daily, estimated to cost $80,000.

N. C., Oxford—The Board of Commissioners and T. G. Stem, mayor, City Hall, will receive bids until Sept. 24th, for complete water purification works, including pumping equipment, etc. W. C. Olsen, Raleigh, is engineer.

N. C., Thomasville—The City plans the construction of new waterworks system to replace deep wells system now in use, estimated to cost $257,000. Engineer not announced.

O., Cleveland Heights—H. H. Smith and R. E. Steffens, 4900 Euclid Ave., Cleveland, O., are having plans prepared for the construction of a 6 story apartment hotel including steam heating system on Cedar Rd. and Fairmount Blvd., estimated to cost $1,000,000. J. F. Steffens, Fidelity Mortgage Bldg., Cleveland, is architect

O., Columbus—Doddington Co., 451 West Broad St., T. A. Jones, purchasing agent, plans to purchase two 150-hp. boilers.

O., Columbus—Neil House Co., 35 South Wall St., awarded the contract for the construction of a 12 story, 188 x 210 ft. hotel on South High St., to Wells Construction Co., 35 South Wall St., estimated to cost about $4,000,000. G. Drach, 1701 Union Trust Bldg., Cincinnati, is architect.

O., Greenville—Director of Public Service, C. E. Williams Clerk, will receive bids until Oct. 1st, for water softening and filtration plant, pumping station, motor driven centrifugal pumps, gasoline engine driven generator, motor driven air compressors, etc. The J. N. Chester Engineers, Union Bank Building, Pittsburgh, Pa., are engineers.

O., Oak Harbor—Board of Trustees of Public Affairs will receive bids until Sept. 30, for improvements to municipal waterworks plant, including addition to pump house and the installation of a motor-driven centrifugal pump.

Okla., Oklahoma City—J. Huckins, Jr., is receiving bids for a power plant, heating system, wells, deep well pumps, high pressure boilers, motors, generators and refrigerating system for the Huckins Hotel, estimated to cost $100,000. W. H. Wells, St. Louis, is engineer.

Pa., Harrisburg—Polyclinic Hospital, H. Gross, Front and Harris Sts., plans the construction of a 3- and 4-story, 110 x 194 ft. hospital on Third Ave. and Fourth St., Kast and Keller, Commonwealth Building, are architects.

Pa., Morrisville—The Borough plans a new storage reservoir and 2 electric pumps, capacity 1,000,000 each, every 24 hours, estimated to cost $48,000. T. B. Stockham, Stockham Bldg., is engineer.

Pa., Pittsburgh — Childrens Hospital Assn., are having plans prepared for an 11 story hospital, estimated to cost $1,000,000. E. P. Mellon, 350 Madison Ave., New York, is architect.

Pa., Shippingport—The Duquesne Light Corp., Pittsburgh, plans the construction of an electric power plant to consist of two, 35,000 kw. units, estimated to cost, $10,000,000.

Pa., York—Community Hotel Co., C. P. Rice, Pres., is receiving bids until Sept. 15th for a 10 story, 97 x 145 ft. hotel. W. L. Stoddart, 50 E. 41st St., New York, is architect.

Tex., Dallas—Dallas Hotel Co., Adolphus Hotel, had plans prepared and soon receives bids for the construction of a 22-story addition to the hotel on Main and Akard Sts., estimated to cost $750,000. A. C. Bossom, 680 5th Ave., New York, and Thomas & Swain, Magnolia Bldg., Dallas, are architects.

Tex., El Paso—R. Orndorff is having plans prepared for the construction of a 10-story, 120 x 130 ft. hotel, estimated to cost $750,000. Trost and Trost, Republic Bldg., are engineers.

Tex., McAllen — Carroll College, Board of Trustees, c/o J. M. Carroll, Pres., are having plans prepared for the construction of administration and dormitory buildings, boiler and engine house, estimated to cost $300,000. H. P. Smith, 312 Natl. Bank of Commerce Bldg., San Antonio, is architect.

Tex., Rusk—City is having plans prepared for waterworks improvements, including dam, pumping plant, etc., estimated to cost $65,000. F. A. Jones, 430 Interurban Bldg., Dallas, Texas, is engineer.

W. Va., Huntington — F. C. Prichard awarded the contract for the construction of a 13 story hotel on 9th Ave., to Hancock Construction Co., 1st Natl. Bk. Bldg., Lynchburg, Va., estimated to cost $1,000,000. Contractor will take bids for heating and ventilating systems.

Wis., Milwaukee—Fleischmann Co., 701 Washington St., awarded the contract for the construction of a 1-story, 50 x 125 ft. cold storage warehouse on 12th St., estimated to cost $40,000. L. L. Tieman, 693 Washington St., New York, is architect. Refrigeration machinery will be required.

Wis., Milwaukee—Milwaukee Macaroni Co., 182 Huron St., awarded the contract for the construction of a 4-story, 168 x 196 ft. factory on North Pierce St., estimated to cost $160,000. Special machinery equipped with individual motors will be required.

Ont., Fort William—North Western Elevator Co., Ltd., plans to rebuild grain elevator destroyed by fire. Equipment, including conveyors, etc., will be required. Estimated cost $100,000.

Que., Ulverton—Canada Paper Co. Ltd., Windsor Mills, are having plans prepared for the construction of a dam and electric power development on the St. Francis River, estimated to cost $800,000. H. Holgate, 285 Beverly Hall, Montreal, is engineer.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Advances exceed the declines in the current market for power-plant and electrical supplies. The principal increases occurred in rubber-covered copper wire (a rise of 10 per cent) and in babbitt metal, red and white lead, linseed oil and wiping cloths. Rivets, structural and boiler, and certain of the refractories declined slightly during the month.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, sing'e jacket	56c. per ft.
Common, 2½-in., 3-ply—80c. per ft. list less	50–10%

Air—Best grade

¾-in., per ft.	3-ply $0 36	4 ply $0.44½

Steam—Discounts from List

First grade 30–5% Second grade 40–5% Third grade 50%

RUBBER BELTING—The following discounts from list apply to rubber transmission belting:

Best grade 50% Second grade 50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40–2½%
Heavy	30–5%

RAWHIDE LACING—For cut, best grade, 45–5%, 2nd grade, 55%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 45–5%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ¼ in.	$0.90
Asbestos for high-pressure steam, ¼ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@ $2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	14@21	20.00	14.00
Colored	9@14.50	17.00	10.50

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13¼ x 13¼	13¼ x 20½
Chicago	16.00	16.00
New York (white, at washeries)	11.50	
Cleveland	$36.00 per M.	$52.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$1.07	$1.16	$1.05

WHITE AND RED LEAD—In 100-lb. kegs, base price in cents per pound:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	14.75	14.00	16.25	15.50
White	14.75	14.00	14.75	14.00

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ½ and smaller	50%	60–10%	70%
Tinned	50%	60–10%	70%

Structural rivets, ½ - ¾, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York $3.75 Chicago $3.50 Pittsburgh $2.60

Boiler rivets, same sizes:

New York $3.85 Chicago $3.60 Pittsburgh $2.90

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$47@52
Chrome cement, 40@ 50% Cr_2O_3, in bulk	net ton	22@27
Chrome cement, 40@ 50% Cr_2O_3, in sacks	net ton	26@31
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	38@40
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	40@47
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	42@43
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	35@42
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	37@39
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	37@39
Chrome ore crude, 40@50%	net ton	17.00@19.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	60.00	61.75	48@52
(35% tin)	28.00	18.50	23@26

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.15	$4.00	$3.80
Flats, square and hexagons, per 100 lb. base	4.65	4.50	4.30

BOILER SPECIALTIES—F. o. b. **New York** or **Jersey City**, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
2	.20	.25	.21
2¼	.23	.29	.23
2½	.24	.33	.28
2¾	....	....	....
3	.30	.41	.32
3¼	.32	.47	.35
3½	.34	.51	.37
4	.43	.64	.47

Tubes 2¼ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¼ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft
No. 14 solid	$41.00 (net)	$ 62.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

		Lead Covered
Less than coil lots	45%	25%
Coils to 1,000 ft.	50%	30%
1,000 to 5,000 ft.	55%	35%
5,000 ft. and over	60%	40%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$61.10	$66.16	$9.90	$11.03	$5.74	$6.16
½	79.20	84.95	13.00	14.49	8.18	8.78
1	112.06	122.19	19.26	21.46	10.65	11.42
1¼	151.62	165.31	25.65	28.33	14.76	15.78
1½	181.28	197.67	34.19	37.77	18.23	19.47
2	248.90	265.94	62.70	69.24	24.29	25.97
2½	385.50	420.48	102.58	111.33	34.71	37.10
3	504.29	548.81	273.40	302.12	51.66	55.63
3½	633.86	688.65	604.03	667.15	69.41	74.19
4	772.62	838.59	697.06	770.99	86.76	92.73

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$21.00
No. 16 cotton reinforced heavy	24.00
No. 18 cotton reinforced light	17.00
No. 16 cotton reinforced light	20.50
No. 18 cotton Canvasite cord	16.50
No. 16 cotton Canvasite cord	18.75

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$0.15	3-amp. to 30-amp.,	100	$0.30
35-amp. to 60-amp.,	100	.30	35-amp. to 60-amp.,	100	.60
61-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
101-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
201-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
401-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:

Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package (500)	$2.85
0–30 ampere, less than standard package	3.15

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No in Package
10	$0.27	$0.32	120	50	$0.40	$0.45	60
15	.27	.32	120	75	45	.55	60
25	.27	.32	120	100	.55	.60	24
40	.27	.32	120	150	.70	.75	24
50	.27	.32	120	200	.95	1.05	24
60	.32	.37	120	300	1.50	1.60	24
				500	2.25	2.40	12
				750	3.75	3.95	8
				1.000	4.00	4.25	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $75.00 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Composition—2 Pc. Plug—Composition	0.8½

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o b. New York,

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$7.11	$9.32	$10 93	$17 60
12	9.51	12 43	13 58	23 98
10	12.65	15 87	17 78	30 09
8	18.04	20.79	23 23	40.70
6	....	.....	32 94	.....
4	....	.....	45 95	.....
2	.....	.....	65 28	.....
1	.....	.....	82 66	.....
0	.....	.....	116.60	.....
00	.....	.....	135 85	.....
000	.....	.....	163.90	.....
0000	.....	.....	192.28	.....

SOCKETS, BRASS SHELL

½ In. or Pendant Cap Key Each	½ In. or Pendant Cap Keyless Each	½ In. or Pendant Cap Pull Each	¾ In. Cap Key Each	¾ In. Cap Keyless Each	¾ In. Cap Pull Each
$0.33	$0.30	$0 55	$0.39	$0.36	$0.61

Less 1-5th standard package	25%
1-5th to standard package	32%
Standard package	37%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:

Less than $25.00 list value	30%
$25 to $50 list value	30–5%
$50 list value or over	35%